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Rayon Reports

Prepared Monthly by American Viscose Corporation, New York, N.Y. MAY, 1949

Plant Modernization, Research Developments Described in 1948 Avisco Annual Report

The 1948 Annual Report of American Viscose underlines the program of the Corporation to improve production. The Report shows that expenditures during 1948 for plant and equipment amounted to $19,835,000. The larger expenditures were for:

1. *Completion of the Meadville plant expansion project. This project increased the plant's capacity by approximately 75%.*
2. *Installation of 51 additional spinning machines at Marcus Hook. Completed in October, 1948.*
3. *Modernization of and additions to steam and electrical generating facilities at the Lewistown and Parkersburg plants.*
4. *Rebuilding spinning machines at the Lewistown and Parkersburg plants.*
5. *The completion of a new water supply system and filter plant for the Sylvania Division at Fredericksburg, Virginia.*

Many other projects were also completed or in progress at the end of the year. Among those in progress were the installation of facilities to further expand production of rayon staple at Nitro and Front Royal and increase the production of cellophane at Fredericksburg.

Research and Development

Cited as the outstanding result of the Avisco research program in 1948 was the development of the "Filamatic" process, a new continuous-spinning method for the manufacture of viscose rayon yarns. Fast, small, and fully automatic, the new machines speed production, reduce handling and produce a high quality product.

Another important recent development is the disposable paper cover for yarn in cake form, exclusive with Avisco. This cover is more economical and convenient for customers and replaces the knitted covers used heretofore.

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Details of these advances and other developments of interest to the textile industry are contained in the 1948 Annual Report of American Viscose Corporation. Copies available on request.

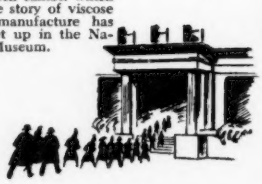
Manufacturer of hose knitter supplies Avisco tire yarn with his machine

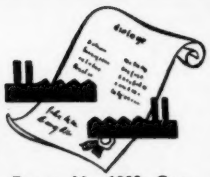
The Fidelity Machine Co. of Philadelphia supplies four ten-pound cones of Avisco tire yarn with each of its standard hose reinforcement machines. The Company reports that after tests they found Avisco tire yarn (2200/980) unequalled in performance and are recommending it to all their customers.

RAYON 20 YEARS AGO

NEW YORK, May 1929—Consumption of rayon in the fancy sweater field is on the increase. One of the reasons for its popularity is the attractive color effects which can be achieved.

WASHINGTON, D.C., May 1929—An exhibit which tells the story of viscose rayon manufacture has been set up in the National Museum.





BERLIN, May 1929—Contracts have been received here for erecting and equipping two rayon plants in Soviet Russia.

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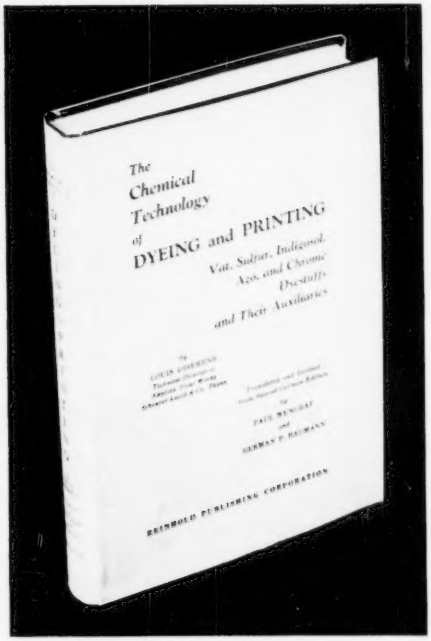
A NEW REINHOLD BOOK

The Chemical Technology of Dyeing and Printing

By Louis Diserens

Technical Director of Alsatian Print Works, Scheurer-Lauth & Co., Thann. Translated and Revised from Second German Edition by Paul Wengraf and Herman P. Baumann



HERE is indeed an outstanding and notable addition to the literature of dyestuffs—the long-desired English translation of the treatise by the famous French textile dyeing authority, Louis Diserens. This translation has been made from the newly released second German edition, and has been carefully revised and edited in the process.

Progress in the manufacture of dyestuffs, industrial and textile chemicals, fibers and resins, is a feature of the book. Since the chemist in the average dyeing and printing plant cannot assimilate all the current literature regarding dyestuff application and related subjects, it is the principal aim of this book to facilitate his task by arranging references in their proper dyestuff groups, and to explain the chemistry of the dyestuffs in relation to their application to textiles.

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TEXTILE RESEARCH JOURNAL

VOL. XIX, No. 5 May, 1949

The Viscosity of Newtonian, Pseudoplastic, and Dilatant Liquids

Use in the Measurement of the D.P. of High Polymers

James G. Krieble * **and John C. Whitwell** †

Contribution of the Textile Research Institute and the Department of Chemical Engineering, Princeton University

Abstract

An equation,

$$\zeta = \frac{\pi R^3}{(Z+3)V}\left(\frac{\Delta PR}{2L}\right)^Z t,$$

for the calculation of the counterpart of viscosity for a pseudoplastic (or dilatant) liquid exists from the relationship existing between $1/t$ and ΔP. Evaluation of ζ and Z defines the liquid property as completely as does η alone for a Newtonian liquid.

The counterpart of viscosity-ratio,

$$\frac{\zeta}{\eta_0} = \frac{4}{Z+3}\left(\frac{\Delta PR}{2L}\right)^{Z-1}\left(\frac{t}{t_0}\right),$$

which is independent of the rate of shear and viscometer dimensions, can be used to determine the intrinsic viscosity, $[\eta]$.

The general character of the change in Z with the concentration is indicated.

THERE HAS ALWAYS BEEN considerable interest in the viscosity of polymer solutions because this property is an index of an average molecular weight of the polymer and is fairly easy to measure. High-polymer materials, such as cellulose and its derivatives, rubbers, starches, and proteins, form solutions in which the coefficient of viscosity is a function of the rate of flow, rather than the constant obtained with simple Newtonian fluids and true solutions. In Figure 1, an example of this "anomalous behavior" is shown for the case of several concentrations of raw cotton dissolved in a 0.5 molar cuprietheylene diamine solution. Each line characterizes the rates of flow of the solution through a capillary, measured at several pressures, and represents one concentration of dissolved cotton per unit volume of solvent. The linear correlation for the solvent is characteristic of a Newtonian liquid under similar conditions and shows that the viscosity, which is inversely proportional to the slope, is independent of the rate of flow, a condition which does not hold for the cellulose solutions.

* Textile Research Institute Fellow.

† Associate Director of Research, Textile Research Institute, and Professor of Chemical Engineering, Princeton University.

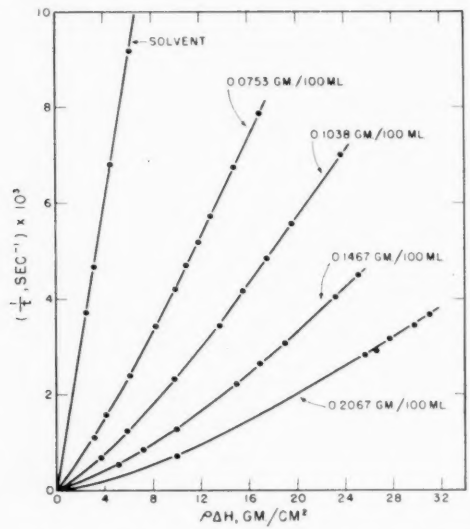

FIG. 1. *Rate of shear-shear stress relations for cellulose in cupriethylene diamine (simplified by omission of viscometer constants).*

A function which expresses the non-linear relationship between the rate of flow and the pressure is essential to useful and comparative measurements on non-Newtonian fluids. Once determined, it can be used in the determination of the intrinsic viscosity, $[\eta]$, or D.P., of the material. Conrad and others have suggested empirical methods (*e.g.*, [2, 7]). Conrad suggests that fluidity, $1/\eta$, be plotted against the "velocity gradient" on double logarithmic scales and that some convenient "velocity gradient," in reciprocal seconds, be chosen as a standard to which all values of fluidity are referred. However, an attempt to determine the intrinsic viscosity at zero velocity gradient results in the value of $[\eta]$ approaching infinity as the "velocity gradient" approaches zero. Authors of earlier papers on "solutions" of polymers [3, 4, 5, 11, 12] have noted that the logarithm of rate of shear is often proportional to the logarithm of shear stress. However, the proportionality constant no longer has the dimensions of viscosity nor are the dimensions identical from one fluid to another. This difficulty may account for the lack of use of the experimentally established relationship in exact mathematical form. It is the purpose of this paper to show how the integrated form may be readily applied to viscometer measurements on pseudoplastic and dilatant fluidity. The constant which replaces viscosity will be designated ξ, and named the "viscosity-counterpart" in order that the difference of its dimensions from those of true viscosity may be clearly recognized. It will be shown that, in the determination of intrinsic viscosity or degree of polymerization, this difference in dimensions vanishes, since the viscosity-counterpart approaches a true viscosity as the concentration approaches zero. Since the expression was developed for use in determining the D.P. of cellulose, the examples will be taken exclusively from data on this material. However, the procedure is generally applicable to any high-polymeric solution which obeys the basic condition of flow, subsequently defined, upon which the method is based.

The Viscosity of Liquids

Newtonian

Classifying liquids with respect to their behavior under different conditions of shear stress in any type of viscometer, a Newtonian liquid [1] is defined as one obeying the condition that the shear stress is directly proportional to the rate of shear. Mathematically, for a capillary viscometer,

$$du/dR = (1/\eta)S, \tag{1}$$

where du/dR is the rate of shear, S is the shear stress and equal to $\Delta PR/2L$, and η is the coefficient of viscosity of the Newtonian liquid. Making the proper manipulations, Poiseuille's Law is obtained:

$$\eta = \frac{\pi R^4 \Delta P}{8LV} t. \tag{2}$$

Many high-polymer solutions do *not* fulfill the condition that the shear stress is directly proportional to the rate of shear as stated by Poiseuille's Law but show instead the properties of a more complicated system.

*Pseudoplastic**

Characteristic rate of shear-shear stress relations are illustrated in Figure 1 and will be seen to be similar to those found by other investigators [3, 4, 5, 11, 12]. In the figure, the coordinates are simplified to reciprocal of time of flow and pressure difference, by the omission of the viscometer con-

*The term "pseudoplastic" has been selected in view of its wide use in current literature. It is recognized that there has been considerable argument regarding the proper designation, such terms as "visco-plastic" and "plastico-viscous" also having adherents.

stants. Cupriethylene diamine, the solvent, which is Newtonian in nature, gives a straight line, whereas the lines for the cellulose solutions approach linearity only at the higher values of ΔP, with gradually decreasing slopes as ΔP approaches zero. Solutions producing this type of curve will be designated "pseudoplastic liquids."* When logarithmic coordinates are used, the lines for both Newtonian and pseudoplastic liquids are straight (Figure 2), but only the slope of the Newtonian liquid has a value of unity, those for the pseudoplastic liquids being greater.

There is considerable experimental evidence that, for a variety of high-polymer solutions, the logarithm of the rate of shear is directly proportional to the logarithm of the shear stress over appreciable ranges. In view of this relationship, a pseudoplastic liquid has been defined in a manner analogous to that of a Newtonian liquid,

$$du/dR = (1/\zeta)(S)^Z, \qquad (3)$$

where Z is a dimensionless constant greater than unity, and ζ is a true constant representing, for pseudoplasticity, the counterpart of Newtonian viscosity. The same equation holds for a dilatant liquid, when Z is less than unity. Regardless of the value of Z, the shear stress will be zero, at, and only at, zero rate of shear. Integrating equation (3), u, the linear rate of flow of a cylindrical layer, is

$$u = \int_{R_c}^{R} \left(\frac{du}{dR}\right) dR = \frac{1}{\zeta}\left(\frac{\Delta P}{2L}\right)^Z \left(\frac{1}{Z+1}\right)(R^{Z+1} - R_c^{Z+1}). \qquad (4)$$

The volume rate of discharge is

$$\frac{V}{t} = 2\pi \int_{R_c}^{0} uR\,dR = \left(\frac{1}{\zeta}\right)\left(\frac{\pi R_c^3}{(Z+3)}\right)\left(\frac{\Delta P R_c}{2L}\right)^Z. \qquad (5)$$

Rearranging equation (5), the pseudoplastic (or dilatant) viscosity-counterpart may be written as follows:

$$\zeta = \frac{\pi R_c^3}{(Z+3)(V)}\left(\frac{\Delta P R_c}{2L}\right)^Z (t). \qquad (6)$$

When $Z = 1$, this equation becomes identical with equation (2); it has been found to hold for starch pastes by Farrow, Lowe, and Neale [3] for low concentrations of starch (<2%) over a 4,000-fold range of shear stress, measurements having been made in both Couette and capillary viscometers on the same samples.

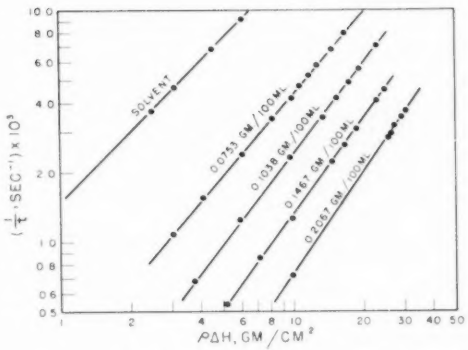

FIG. 2. *Rate of shear-shear stress relations for cellulose in cupriethylene diamine (simplified by omission of viscometer constants).*

From equation (6), any liquid which obeys the relationship postulated by equation (3) can be defined by stating the values of ζ and Z. The value of ζ is independent of the velocity gradient and of the dimensions of the particular viscometer used. A Newtonian liquid will have a value of $Z = 1$, a pseudoplastic $Z > 1$, and a dilatant $Z < 1$. Thus, *equation (6) may be considered as a generalized form of Poiseuille's Law when rate of shear may be expressed as a power function of the shear stress.*

Viscosity Ratios

Since the interest in viscosity of polymers is directed toward the determination of the intrinsic viscosity, direct calculation of the viscosity-ratio-counterpart, ζ/η_0, is desirable. Dividing equation (2) for the Newtonian solvent, both taken in a single viscometer so that constants will be the same:

$$\frac{\zeta}{\eta_0} = \frac{4}{(Z+3)}\left(\frac{\Delta P R_c}{2L}\right)^{Z-1}\frac{t}{t_0} = \zeta_r. \qquad (7)$$

This equation reduces to $\eta_r = t/t_0$ when $Z = 1$, the case when both the solution and the solvent are Newtonian, their densities are equal, and the kinetic energy correction is negligible.

Intrinsic Viscosity

Since the intrinsic viscosity [6, 8, 9, 10] requires an extrapolation to zero concentration, several

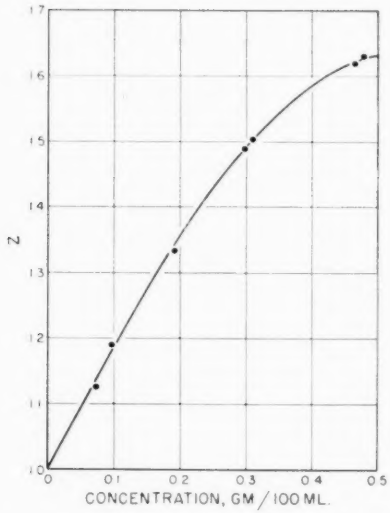

FIG. 3. *Non-Newtonian parameter, Z, as a function of concentration, for cellulose in cupriethylene diamine.*

raw cotton solutions were studied over a range of concentration from 0.05 percent to 0.5 percent (0.05 to 0.5 gm./100 ml.). The values of Z obtained at different concentrations are illustrated in Figure 3. The effect of rate of shear is large, and does not become negligible even at very great dilutions. However, as C approaches zero, Z does approach 1, as must be the case when the solvent is Newtonian. From this observation, it has been concluded that the limiting value of $(\zeta/\eta_0 - 1)/C$ is dimensionally equivalent to $\lim_{C \to 0} \eta_{sp}/C$ and is, therefore, a measure of $[\eta]$, which is independent of rate of shear and viscometer dimensions. Conrad noted that extrapolation of his viscosity ratios was impossible because of the log-log relationship on which were based all of his "velocity gradient" corrections. He stated: "A means for extrapolating viscosity from intermediate to zero velocity gradients will no doubt be worked out eventually." The proposal in this paper does so.

An example of an application of this method to the determination of $[\eta]$ of raw cotton in cupriethylene diamine is given in Figure 4. Log $(\zeta/\eta_0 - 1)/(C)$, using ζ/η_0 from equation (7), is linear with respect to C, and log $[\eta]$ is the intercept. Linearity over the same range is not obtained using the simple relationship $\eta_r = t/t_0$.

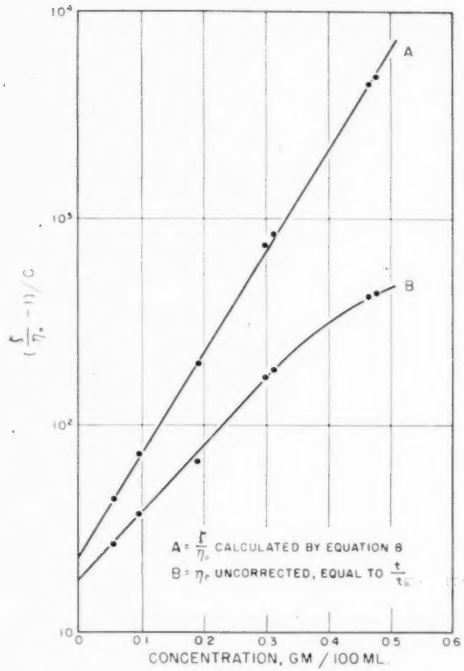

FIG. 4. *Specific viscosity as a function of concentration, from viscosity-ratio-counterpart and uncorrected viscosity-ratio data.*

Conclusions

The flow characteristics of a fluid obeying the condition that the logarithm of the rate of shear is directly proportional to the logarithm of shear stress can be completely defined by means of two constants, ζ and Z. By using values of ζ_r, measured at different concentrations, a unique determination of intrinsic viscosity can be made, independent of instrument dimensions and rate of shear.

No increase in experimental work is required for evaluation of ζ and Z beyond that of any previous method for non-Newtonian liquids, although a number of determinations of flow times, at various pressure gradients, are required in contrast to the single measurement for a Newtonian liquid. The increase is inherent to evaluation of pseudoplastic liquids because of the greater number of degrees of freedom involved in their flow characteristics.

Future Work

The concept of the use of viscosity-counterparts in the evaluation of intrinsic viscosity was developed in a research requiring very precise differentiation between the D.P. (or equivalent) of various closely associated cellulose samples. Application of the complete relations between rate of shear and shear stress as here utilized will be the subject of a future publication, dealing with the estimation of molecular damage as affected by various types of cotton processing.

Appendix

Determination of Viscometer Constants

In applying equation (7), the dimensions and constants R, L, ΔP_m, and V, of each viscometer must be known.

For Cannon-Fenske viscometers or any similar capillary type, these quantities may be precisely determined by a few additional measurements on a Newtonian liquid. If viscosity and density are known, the following expressions may be written:

$$\frac{1}{Kt} = \Delta P_m + \Delta P_a;$$

whence

$$\Delta P_m = -\Delta P_a \quad \text{at} \quad 1/t = 0,$$

and

$$\Delta H_m = \Delta P_m / \rho g. \tag{8}$$

Furthermore,

$$\eta = k\rho t,$$

where

$$k = \frac{\pi R_c^4 \Delta H_m g}{8LV} \text{ (from equation (2)).}$$

Therefore

$$R_c = \left(\frac{8kLV}{\pi \Delta H_m g}\right)^{\frac{1}{4}}. \tag{9}$$

ΔH_m was calculated from equation (8) where the values of ΔP_m were determined by the least-squares method. The data for water and cupriethylene diamine ($CuEn^2$), measured in one viscometer, are shown in Figure 5.

Using the data for water and cupriethylene diamine, R_c was calculated from equation (9) after L and V had been determined. L, the length of the capillary, was measured with a cathetometer. V, the volume of liquid flowing during a test, was calculated from the weight of mercury contained in the bulb between the marks. The viscometer was inverted and the measuring bulb was filled with mercury which was then permitted to flow

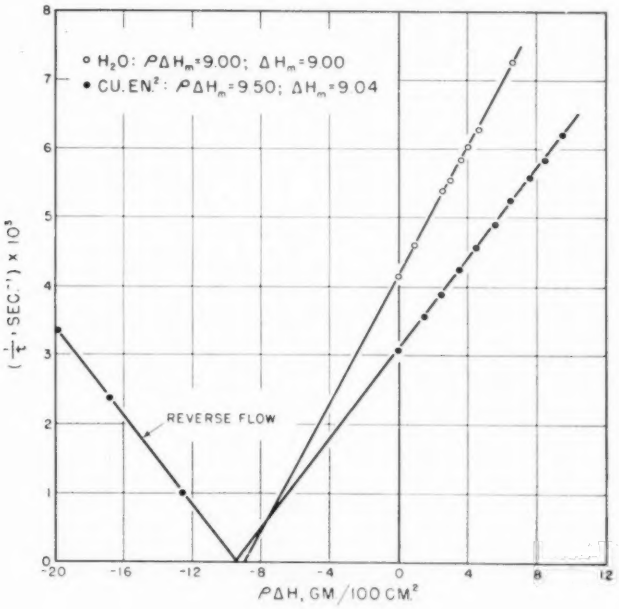

FIG. 5. *Viscometer calibration, for Newtonian liquids.*

TABLE I

ΔP*	$1/t$**	rhes-counterpart,† $1/\zeta$	rhes,‡ at 1,500 sec.$^{-1}$
	Cotton 54, $Z = 1.497$		
28.3	.01472	.2228	4.46
23.3	.01111	.2251	4.51
18.0	.00749	.2233	4.47
13.1	.00466	.2236	4.53
	Cotton 111, $Z = 1.295$		
28.3	.02641	1.180	6.44
23.3	.02081	1.196	6.41
18.2	.01496	1.184	6.42
13.3	.00990	1.186	6.48

* Taken from Figure 5B, reference [5].
** $1/t = 3\pi R^3 G/8V$, where G is mean velocity gradient (from Table II, reference [5]).
† Calculated by equation (8), where $R_c = .048$ cm., $V = 5$ cm.^{3}, and $L = 2.5$ cm.
‡ Taken from Table II, reference [5].

out slowly so that the mercury contained between the marks could be caught in a weighing bottle. Several determinations were made on each viscometer, with excellent agreement.

Example of Use of Equation (6)

Values of viscosity-counterpart for Jelinek's cottons 54 and 111 [5] have been calculated by equation (6). The slopes, Z, were obtained by the method of least squares from Figure 5B of that article. Dimensions of the viscometer were given. Values of time of flow were calculated for successive 5-ml. volumes discharged from the burette-type viscometer. The results are summarized in Table I, reported as fluidity-counterparts, $(1/\zeta)$, for comparison with Jelinek's values, which had been calculated by Conrad's method [2]. The precision of the two methods is in the same range, but the values calculated from equation (6) are independent of both the rate of shear and the viscometer dimensions, while those calculated by Conrad's method are dependent upon the arbitrarily selected rate of shear.

NOMENCLATURE

C	concentration, gm. solute/100 ml. solvent
ΔH_m	mean head of any viscometer, cm.
K	viscometer constant, of units equivalent to $1/t\Delta P$
L	length of viscometer capillary, cm.
ΔP	total hydrostatic pressure on viscometer, (gm.)/(cm.)(sec.)^2
ΔP_m	mean hydrostatic pressure on viscometer, (gm.)/(cm.)(sec.)^2
ΔP_a	hydrostatic pressure applied to viscometer, (gm.)/(cm.)(sec.)^2
R	radius of any cylindrical shell, cm.
R_c	radius of viscometer capillary, cm.
S	shear stress, $\Delta PR/2L$, gm./cm. sec.^{2}
V	volume of liquid flowing through capillary in time t, cm.^{3}
Z	$d(\log 1/t)/d(\log \Delta P)$
g	gravitational constant, cm./sec.^{2}
0	subscript, refers to solvent
t	time of flow, seconds
u	velocity of flow, cm./sec.; du/dR is rate of shear
k	viscometer constant, cm.^{2} sec.^{2}, $\eta/\rho t$
ζ	viscosity-counterpart, (poises)^Z sec.$^{Z-1}$
ζ_r	viscosity-ratio-counterpart, $\zeta\ \eta_0$
η	coefficient of viscosity, poises
$1/\eta$	fluidity, rhes
η_r	viscosity ratio, η/η_0
η_{sp}	specific viscosity, $\eta_r - 1$. (Also called "viscosity ratio increment")
$[\eta]$	intrinsic viscosity, $\lim_{C=0} \eta_{sp}/C$ (Newtonian); $\lim_{C=0} (\zeta\ \eta_0 - 1)/C$ (non-Newtonian)
ρ	density, gm./cm.^{3}

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Improved Single-Unit Schiefer Abrasion Testing Machine*

Herbert F. Schiefer, Lawrence E. Crean, and John F. Krasny

Abstract

An improved single-unit Schiefer abrasion testing machine was developed. It can be adapted for testing a great variety of materials under a wide range of test conditions. Different types of specimen holders and abradants can be used with the machine. Both the pressure and the tension on the specimen can be fixed at selected values and maintained constant throughout the test period. A variety of materials, including woven, knitted, and coated fabrics, plastics, paper, leather, and other materials, were abraded with the machine. The abrasive wear of each material was found to be extremely uniform over the abraded area. The effect of the amount of plasticizer on the resistance to abrasion of plastics was readily measured. The rate of abrasion was directly proportional to the amount of plasticizer present. The abrasive wear in tests of woven fabrics appeared very similar to that which occurred in service. A quantitative method based upon the change in electrical capacitance of the specimen with abrasion was described for evaluating the amount of abrasion. A quantity which is a measure of abrasive destruction or ruin was defined. This quantity was used to obtain an iso-ruin map of a large area of a trouser leg. This iso-ruin map showed very clearly a number of areas at which excessive wear in service had occurred. The change of the abradant during abrasion tests is discussed. Carborundum paper, a generally used abradant, decreased very greatly in abrasive power. The spring steel blade abradant remained essentially constant, although in testing one resin-finished fabric the surfaces of this abradant became coated with the resinous substance, which greatly increased its abrasive power.

I. Introduction

The experimental machine initially constructed to produce uniform abrasive action over a surface and from every direction in the plane of the surface in accordance with the mathematical solution † for obtaining uniform abrasion demonstrated very definitely the soundness of this type of machine. It was found desirable, however, to construct a much more rigid machine in order to maintain parallel alignment of the two axes of rotation. In redesigning the machine, several other improvements were made which facilitate testing, adapt the machine for testing a greater variety of materials, and increase the range of testing conditions. The new machine described in this paper meets these requirements very well.

* Permission to publish this paper was granted by the Office of The Quartermaster General, War Department, which sponsored and supported this work as part of a broad and long-term fundamental program of research on abrasion. This paper also appears in the May, 1949, issue of *J. Research Natl. Bur. Standards.*

† Schiefer, Herbert F., Solution of Problem of Producing Uniform Abrasion and Its Application to the Testing of Textiles, *J. Research Natl. Bur. Standards* **39**, 1-10 (1947), RP 1807; TEXTILE RESEARCH JOURNAL **17**, 360-8 (July 1947).

II. Description of Machine

The general appearance of the improved single-unit ‡ Schiefer abrasion testing machine is shown in Figure 1. The specimen is in constant contact with the abradant during a test. The specimen and the abradant rotate in the same direction and with approximately the same angular velocity, 250 r.p.m., each about its own axis. These axes are spaced 1 inch apart and are parallel. The framework of the machine is a single heavy rigid casting. Ample interior space is provided for gears, which can be inserted through small openings in the rear of the casting. The schematic drawing in Figure 2 shows the arrangement of the gears and the several rotating shafts used to produce the rotation of the specimen and the abradant. Each shaft rotates in two ball bearings. The gears of one shaft are primed, thereby making the shafts rotate at slightly different speeds. This speed difference prevents one and the same element of the abradant from acting on one and the same area of the specimen during each rotation.

‡ A four-unit Schiefer abrasion testing machine has recently been constructed and will be described in a subsequent paper.

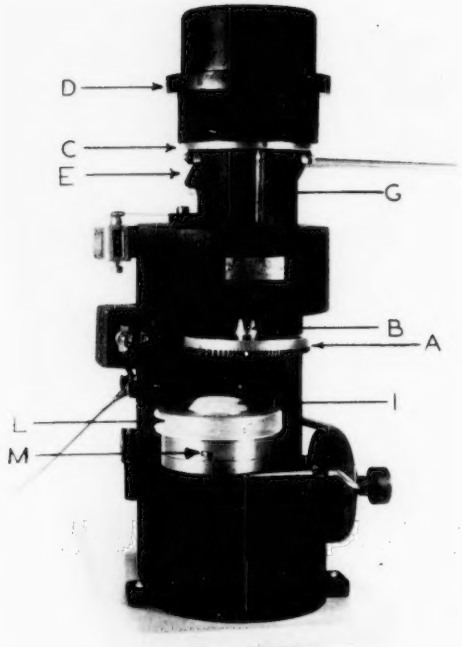

FIG. 1. *Schiefer abrasion testing machine ready for a test.*

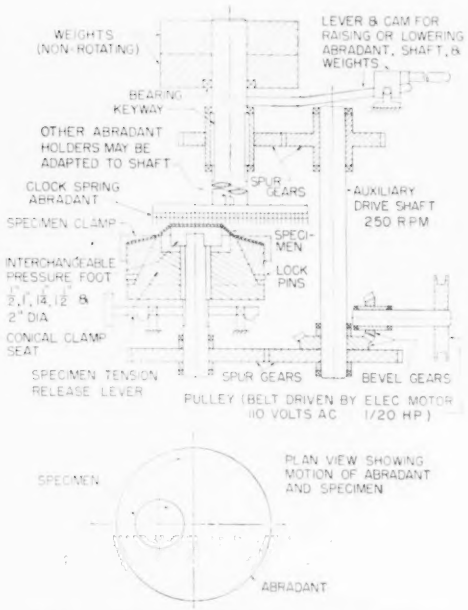
WEIGHTS (NON-ROTATING)
LEVER & CAM FOR RAISING OR LOWERING ABRADANT, SHAFT, & WEIGHTS
BEARING KEYWAY
OTHER ABRADANT HOLDERS MAY BE ADAPTED TO SHAFT
CLOCK SPRING ABRADANT
SPUR GEARS
AUXILIARY DRIVE SHAFT 250 R.P.M.
SPECIMEN CLAMP
SPECI-MEN
INTERCHANGEABLE PRESSURE FOOT 1/2", 1", 1 1/4", 1 1/2" & 2" DIA
LOCK PINS
CONICAL CLAMP SEAT
SPECIMEN TENSION RELEASE LEVER
SPUR GEARS
BEVEL GEARS
PULLEY (BELT DRIVEN BY ELEC MOTOR 110 VOLTS AC 1/20 H.P.)
SPECIMEN
PLAN VIEW SHOWING MOTION OF ABRADANT AND SPECIMEN
ABRADANT

FIG. 2. *Schematic drawing of Schiefer abrasion testing machine.*

Different kinds of abradants, A, can be attached to the bottom of the abradant shaft, B. The abradant surface lies in a plane perpendicular to the shaft axis. This shaft has two keyways cut lengthwise for the entire length of the shaft. It can be moved vertically through a bushing, which forms the rotating shaft of the gear that is driven by a gear fastened to the auxiliary drive shaft. To the top of the abradant shaft is attached, through radial and thrust ball bearings, an aluminum cap, C, which serves as support for adjustable weights, D, to produce constant pressure of the abradant on the specimen throughout the test. A yoke, E, actuated by a cam is provided for raising or lowering the abradant. A key on the inside of the aluminum cap can slide in a vertical keyway, G, of the main casting and keeps the cap and weights from rotating.

To the top of the specimen shaft is attached a presser foot which fixes the area of the specimen, I, that is abraded. Different sizes and shapes can be used. In the upper portion of the specimen shaft are cut two keyways. A conical clamp seat with two keys is fitted to the specimen shaft and rotates with it. It can move freely vertically on the shaft. A cam is provided at the bottom, with two ball bearing contacts for raising the conical clamp seat. The clamp, L, holding the specimen, fits on the conical seat and can be fastened to it by two lock pins, M, by merely rotating the clamp slightly. The clamp and specimen can be removed quickly in the same simple manner for examination and measurement of the amount of wear. The specimen can then be returned to the machine without disturbing its position in the clamp and the abrasion test can be continued. The textile specimen, I, is mounted in the clamp in a relaxed state under reproducible conditions. When the specimen clamp is locked to the conical clamp seat and the conical clamp seat is lowered by turning the cam, the combined weight of the conical clamp seat and specimen clamp is suspended by the specimen over the presser foot fastened to the top of the shaft. This places the specimen under constant tension throughout the test with take-up of any stretch of the specimen. Different tensions can be obtained by varying the weight of the conical clamp seat or by the addi-

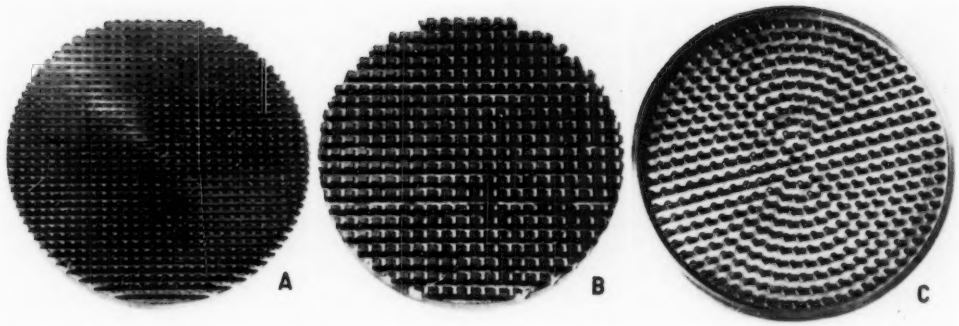

FIG. 3. *Interchangeable abradants: A—Cross-cut spring steel blade abradant. B—Cross-cut high-speed tungsten tool steel abradant. C—Carboloy rod abradant.*

tion of auxiliary weights. It is apparent that the shaft, presser foot, conical clamp seat, specimen clamp, and specimen rotate as one unit under the described conditions.

The successive steps for mounting a circular textile specimen are important. The lower half of the clamp is placed over a template with a hub projecting a given distance, which is adjustable, through the center of the clamp. The circular specimen is placed centrally over the hub and the annular conical ring is placed on top of the specimen so that the recess cut in the rim of the ring registers with a pin in the lower half of the clamp. The upper half of the clamp is then screwed to the lower half, thereby clamping the specimen evenly and securely. When the clamp is lifted from the template, the specimen is in the prescribed relaxed state. The twofold reason for mounting the specimen in this relaxed state is to obtain even circumferential tension on the specimen and to provide enough material so that the portion of the specimen which is in contact with the presser foot projects sufficiently above the clamp for the abrasion test. It is obvious that other types of specimen clamps can be used for testing non-textile materials. Clamps for testing small cylindrical specimens of plastics and other solid materials have been constructed.

III. Abradants

Different abradants may be used interchangeably in the machine. The abradant, A, in Figure 1 consists of closely spaced parallel spring steel blades, the edges of which have been ground to lie in the same plane. The abradant in Figure 3A is similar except that notches were cut in the blades. The abradant in Figure 3B is similar to the latter except that thicker blades of high-speed tungsten tool steel were used. The abradant in Figure 3C consists of 397 small rods of carboloy, the ends of which were ground to lie in the same plane. A similar abradant was used in some tests in which pyrex glass rods were used instead of carboloy. It is planned to make others in which rods of high-speed tungsten tool steel and synthetic sapphires will be used. An adapter has been constructed in which duck, cloth, sandpaper, emery paper, and similar abrasives may be used. The abrasive is mounted under uniform tension and in a plane at right angles to the axis of rotation. Obviously, many other types of abradants can be used, depending upon the kind of test desired and upon the kind of material being tested.

IV. Typically Worn Specimens

Specimens of woven fabric, fleeced knitted fabric, pile fabric, coated fabric, coated glass fabric, graph paper, leather, plastic, and printed enamel floor covering have been tested. The wear on all of these materials was extraordinarily uniform over the abraded area. The woven fabrics are of special interest. The tests on them were discontinued when one set of threads (warp or filling) was completely worn away, while the other set of threads was still intact, as shown in Figure 4. Figure 5 shows abraded areas above the knee of two trouser legs. A higher magnification of the abraded area in Figure 5B is shown in Figure 6. Examination of worn garments indicated that the wear shown by these trouser legs is typical of the abrasive wear of woven fabrics in serv-

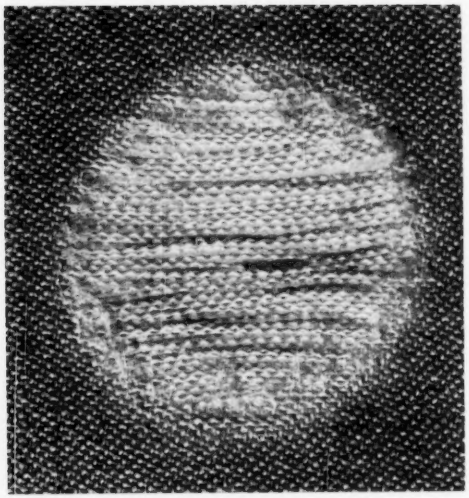

FIG. 4. *Magnified appearance of an abraded woven specimen.*

ice. The striking similarity of the abrasion obtained with the machine and in service is evident.

A special application of the machine described is for evaluating the effect of wet cleaning solutions on printed enamel felt-base floor coverings. The specimen is placed at the bottom of a shallow cylindrical cup and the cleaning solution is placed on it. The abradant used is a nylon-bristle brush. Some of the floor coverings tested had good resistance to washing with soap and soda solution at 45°C. Others were poor in this respect.

V. Quantitative Method for Measuring Abrasion of Fabrics

Consideration was given to a quantitative measurement of the amount of abrasion during a test. This measurement should not disturb or affect the specimen and should be simple, rapid, and sufficiently sensitive. The capacitance method described below seems to meet these requirements.

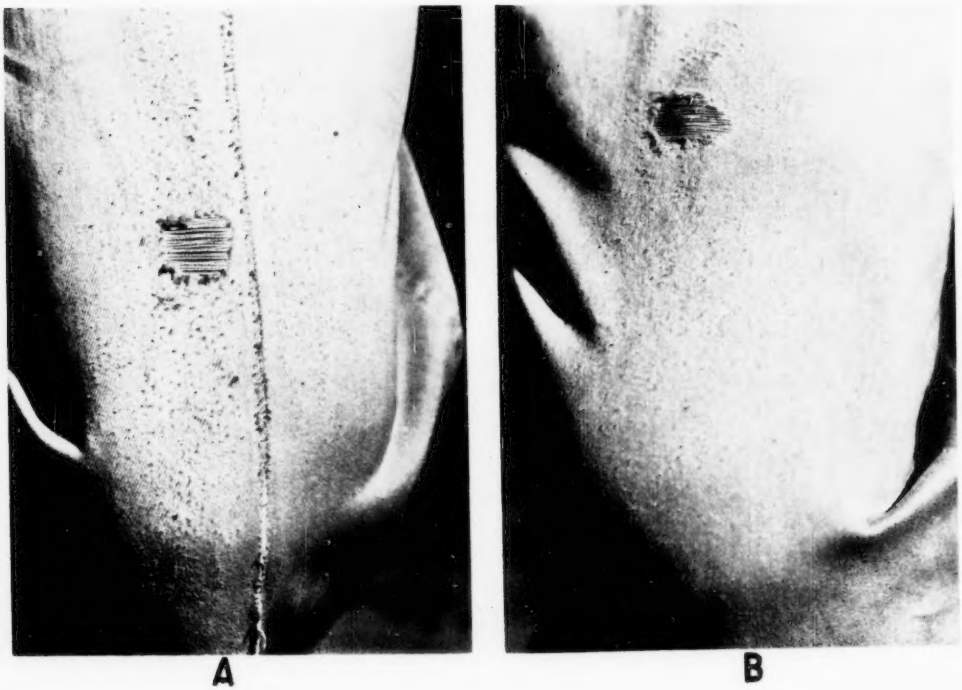

FIG. 5. *Abraded areas of two trouser legs.*

A capacitor,* shown in Figure 7, was attached to a capacitance test set which is normally used to measure the capacitance between the electrodes of vacuum tubes. This set operated at a frequency of 465,000 cycles per second. The capacitor is of the guard-ring type. The island electrode is 1 cm. in diameter. The outside diameter of the annular guard-ring electrode is 3 cm. The island and guard rings were so constructed that the specimen clamp from the abrasion machine could be readily inserted in the capacitor in such a manner that the clamp was suspended by the worn area of the specimen over the island and the guard electrodes. The third electrode is mounted in a heavy, hinged lid which can be swung down to a fixed stop after the specimen and clamp are inserted. This third electrode forms part of a micrometer head for adjusting the distance between it and the island electrode to precise, known values. The construction of the capacitor is very heavy and rigid.

The measuring procedure consists in adjusting the distance between the electrodes to a value slightly in

*Dr. Charles Moon of the National Bureau of Standards suggested the essential design features of this capacitor.

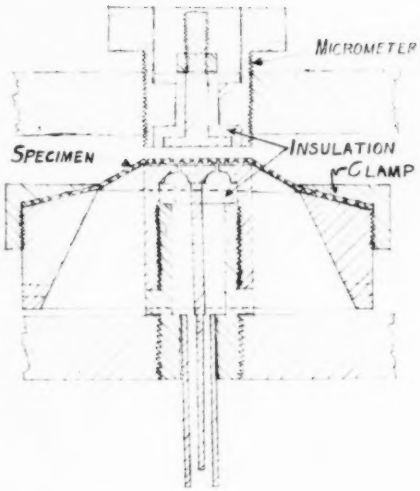

FIG. 7. *Abraded specimen suspended over electrode in capacitor.*

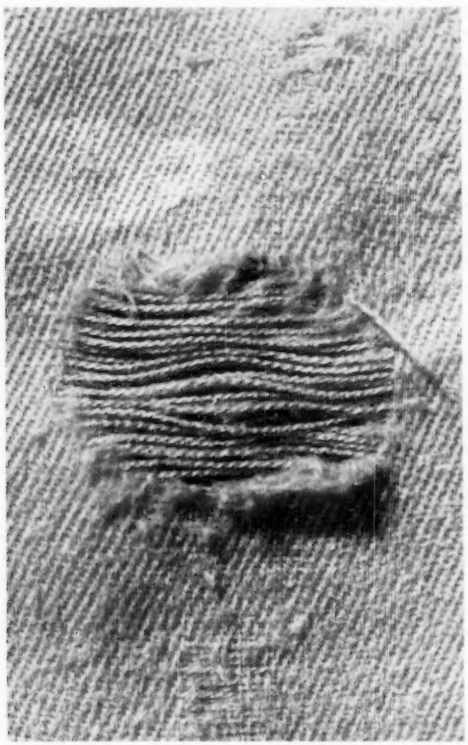

FIG. 6. *Magnified appearance of abraded area of the trouser leg, B, Figure 5.*

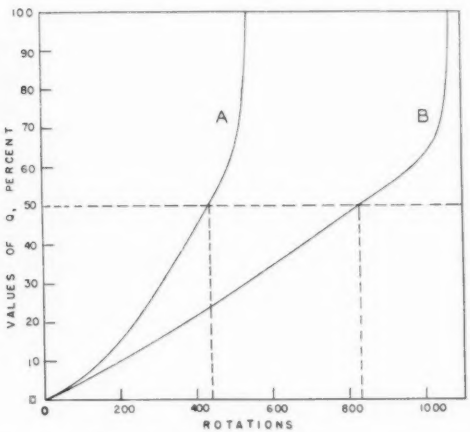

FIG. 8. *Change in the parameter Q with rotations of abrasion for two fabrics.*

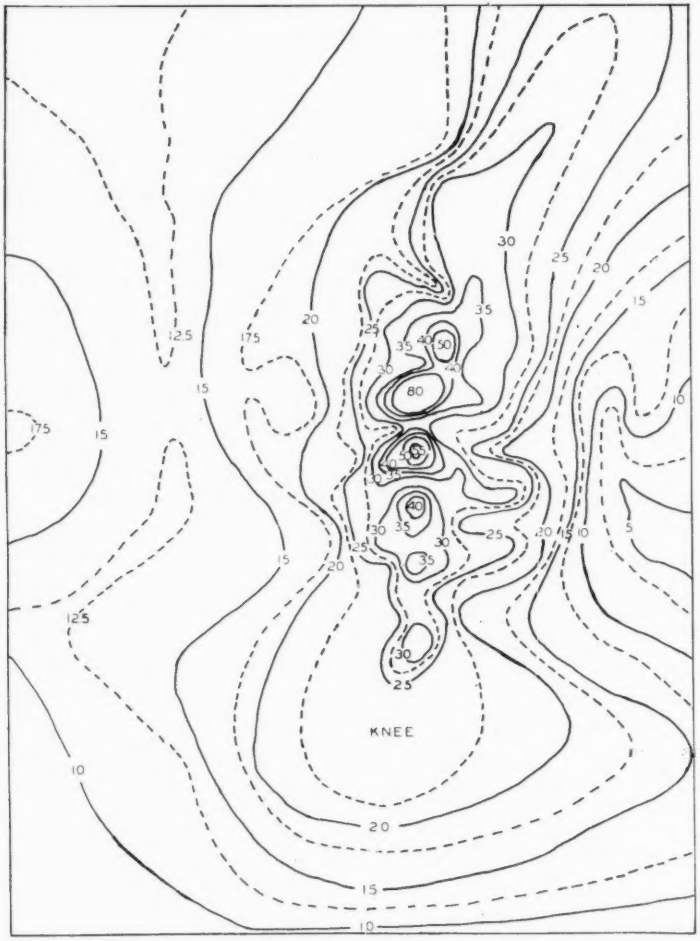

FIG. 9. *Iso-ruin map of the worn trouser leg, B, Figure 5.*

excess of the thickest specimen to be tested. The capacitance C_0 with the unworn specimen in the capacitor is measured and also the capacitance C_a of the air without a specimen. The specimen is then abraded for R rotations against the abradant in the abrasion machine and the capacitance C_R of the abraded specimen is measured. The value Q is then computed by means of the formula

$$Q = \frac{C_0 - C_R}{C_0 - C_a} \times 100.$$

It can be taken as a measure of destruction or ruin by abrasion, expressed as a percentage. If a number of values of Q are obtained for various values of R, a wear curve can be obtained by plotting Q against R, as shown for fabrics A and B in Figure 8. For comparative testing, some function of R, such as $\log_{10} R_{50}$ where R_{50} is the number of rotations for which Q is 50 percent, is suggested as a suitable criterion or wear index. It is believed that this index would correlate well with service-test results. Confirmation of this will of course have to wait until adequate service and

laboratory wear-test results are available. The supplier of fabrics A and B stated that fabric B was definitely superior to fabric A according to service performance of these two fabrics.

The application of the capacitance measurement for evaluating quantitatively the abrasive wear of garments is of special interest. The trouser leg shown in Figure 5B was opened along the inside seam and a very large number of capacitance measurements were made of the area shown in Figure 5B. For each measurement a value of Q was computed using as a value of C_0 that which was obtained for the least worn area. These values of Q were accurately plotted according to the position of each measurement. From

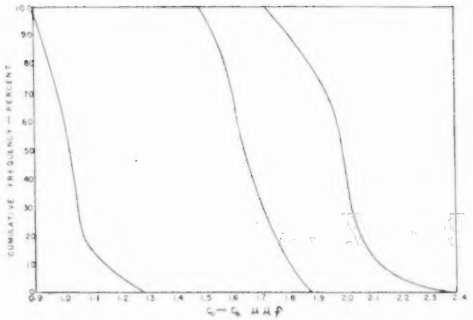

FIG. 10. *Cumulative frequency curves of capacitance showing variations within three cotton fabrics.*

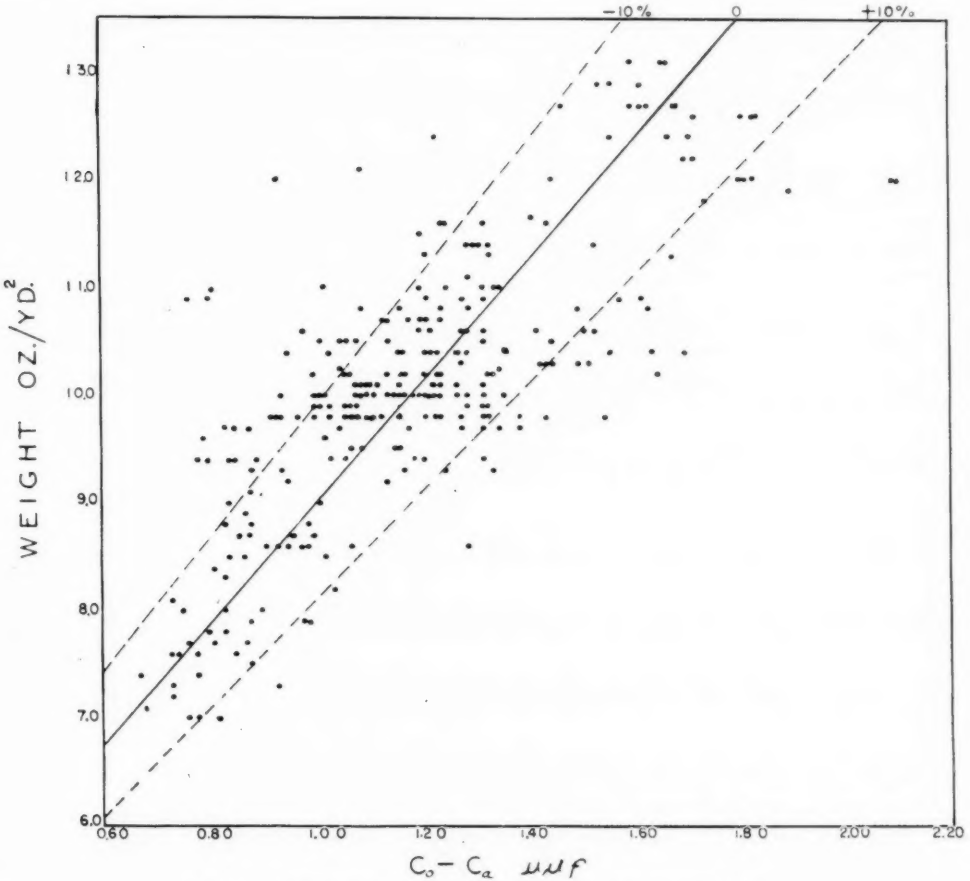

FIG. 11. *Relation between weight and capacitance of cotton fabrics.*

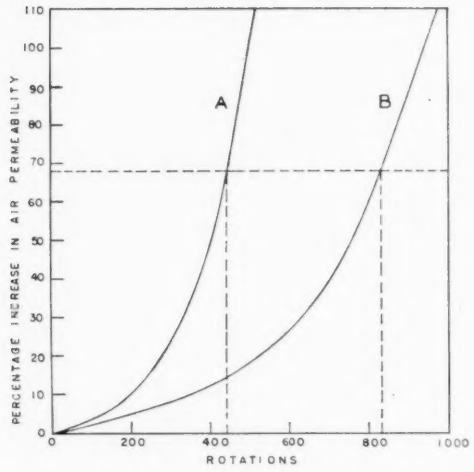

FIG. 12. *Change in air permeability of two fabrics with rotations of abrasion.*

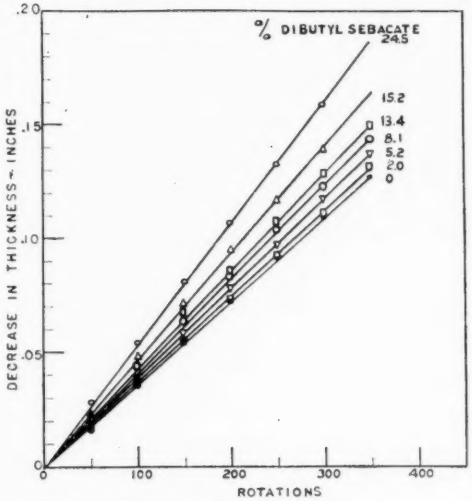

FIG. 13. *Relation between decrease in thickness and rotations of abrasion of cellulose acetate butyrate containing varying amounts of plasticizer.*

these plotted values of Q it was very easy to chart the iso-ruin lines of the parameter Q, as shown in Figure 9. By comparing this iso-ruin map with the actual photograph in Figure 5B, it can be seen that Q closely approximates the value of 50 percent in several areas where the one set of threads is practically worn away. A direct comparison of this iso-ruin map and the actual fabric is of course much more striking and convincing. A simple capacitance device could be arranged for obtaining the iso-ruin map of trousers without the necessity of opening any of the seams. This would allow the trousers to be worn again after each evaluation of the amount of wear from the iso-ruin map.

The iso-ruin-map technique can also be used to explore the uniformity of a fabric, especially of the distribution of finishing agents in a fabric which are moisture-sensitive. In Figure 10 are plotted the cumulative frequency distributions of $C_0 - C_a$ for three unworn cotton fabrics. It can be readily seen

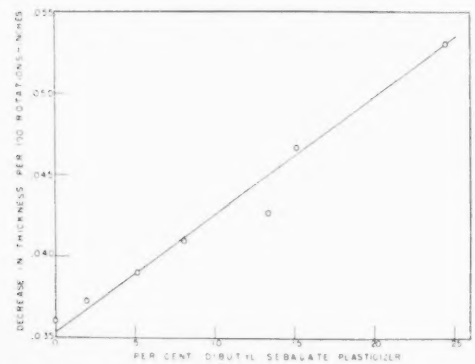

FIG. 14. *Rate of abrasion of cellulose acetate butyrate as measured by change in thickness per 100 rotations.*

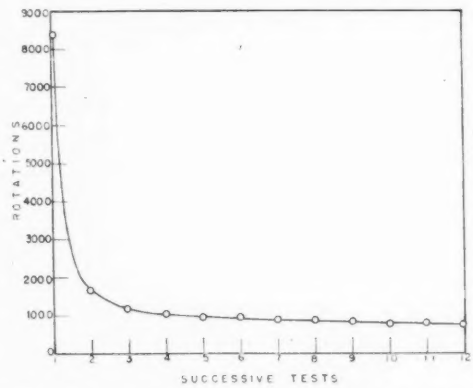

FIG. 15. *Curve showing increased rate of abrasion in successive tests owing to deposit of resin finish on abradant.*

that these three fabrics contain areas for which $C_0 - C_a$ departs considerably above and below the average. The different values of $C_0 - C_a$ for areas 1 cm. in diameter within fabrics arise from variations in the yarn number, ends and picks per inch, twist of the yarns, and amount of sizing. These factors affect the weight of the fabric in 1-cm. diameter areas and also the amount of moisture contained in these areas. Changes in the latter affect the values of $C_0 - C_a$ greatly.

In connection with the foregoing, the following data are of interest. In Figure 11 are plotted the weights in oz. yd.^{2} of many unabraded specimens, taken from 69 different cotton fabrics, against $C_0 - C_a$. The scattering of the points is attributed primarily to the nonuniformity within each of these fabrics. Another contributing cause is the fact that the weight was determined on an area of fabric which was 90 times the area used in the capacitance measurement. However, in view of the very large number of values plotted in Figure 11, it is evident that for the over-all data the quantity $C_0 - C_a$ is directly proportional to the weight, oz. yd.^{2}. It is reasonable to conclude, therefore, that when the value of $C_0 - C_R$ in an abrasion test is one-half of the value of $C_0 - C_a$ (*i.e.*, when Q is 50 percent) then the weight per unit area of the abraded portion of the specimen is one-half of the weight before the abrasion. A specimen which is abraded to this degree should have approximately one set of threads destroyed, as was indicated by a number of abraded areas in Figure 9.

Another quantitative measurement which can be made on the worn area without disturbing or affecting the specimen is that for air permeability. The percentage increase in air permeability of the two fabrics of Figure 8 was measured immediately after each capacitance measurement. The specimen clamp from the abrasion machine was inverted and placed directly in the air-permeability apparatus * and the air flow was measured at a pressure differential of 0.5 inch of water across the specimen. In Figure 12 the percentage increase in air permeability over the unabraded specimen is plotted against the number of rotations of abrasion. It can be seen that the percentage increase in air permeability increases rapidly with the number of rotations of abrasion. The percentage increase at the number of rotations which corresponds to the value of 50 percent for Q in Figure 8 is 68 percent for both fabric A and fabric B. This is merely a coincidence and it is not expected that this relationship would be found generally for other fabrics. The percentage increase in air permeability may have merit as a quantitative measurement of abrasion of some fabrics.

* Schiefer, Herbert F., and Boyland, Paul M., An Improved Apparatus for Measuring the Air Permeability of Fabrics, *J. Research Natl. Bur. Standards* **28**, 637–42 (May 1942), RP 1471.

VI. Application for Evaluating the Effect of Plasticizer on Resistance to Abrasion of Plastics

Small cylinders of cellulose acetate butyrate containing various percentages of dibutyl sebacate were abraded, using the abradant shown in Figure 3A. The cylinders were ½ inch long and were machined to a diameter of 0.450 inch. The weight and thickness (length of cylinder) were measured before the test and at regular intervals during the abrasion test. The decrease in weight was directly proportional to the decrease in thickness, which is plotted in Figure 13 against the number of rotations during which the specimen was in contact with the abradant. The effect of the amount of plasticizer on the resistance to abrasion was readily measured. The decrease in thickness per 100 rotations is plotted against the amount of plasticizer in Figure 14, and shows that the rate of abrasion increases directly with the amount of plasticizer.

VII. Effect of Abrasion Tests on the Abradant

Some abradants are considerably affected or changed during an abrasion test. This is particularly

TABLE I. EFFECT OF FIVE SUCCESSIVE TESTS WITH SAME CARBORUNDUM WATERPROOF ABRASIVE PAPER ON ABRASION RESULTS OF DIFFERENT FABRICS

Fabric no.	Rotations of abradant to destroy specimen				
	1st test	2nd test	3rd test	4th test	5th test
1	58±3	110±5	127±7	133±7	132±5
2	77±5	134±16	186±19	187±13	196±15
3	84±3	127±5	147±11	166±12	149±6
4	90±6	158±9	174±10	193±12	189±19
5	92±6	181±17	213±18	230±10	215±14
6	104±5	221±20	260±17	292±26	306±48
7	110±4	252±20	301±26	278±27	322±55
8	115±4	252±7	278±9	290±7	290±9
9	126±9	228±18	276±33	302±21	287±16
10	135±4	253±6	274±11	272±12	281±11
11	135±10	311±29	354±32	401±38	398±29
12	138±4	299±8	345±14	371±10	395±7
13	143±4	298±18	335±8	342±9	391±22
14	145±13	500±73	708±166	887±125	1105±279
15	152±5	417±20	505±23	540±40	591±22
16	193±6	494±27	563±22	686±76	866±71
17	475±29	1231±145	2106±229	2119±105	2747±760

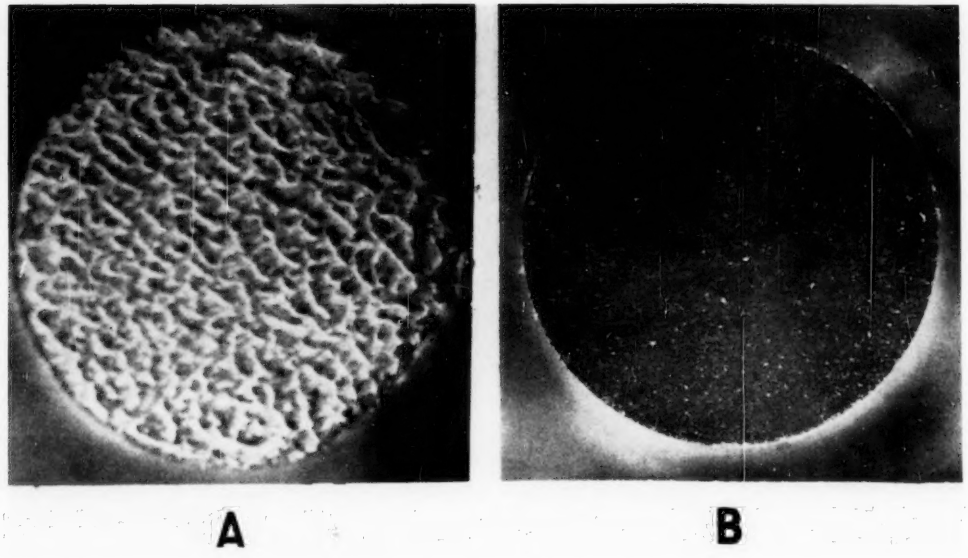

FIG. 16. *A—Surface of a pyrex rod of abradant coated with resin finish in abrasion test. B—Surface of a pyrex rod of abradant without the resinous coating.*

true when abrasive papers, abrasive cloths, and fabrics are used as abradants and is shown by the results for 17 fabrics given in Table I. Five successive tests were made of each fabric with the same piece of carborundum waterproof abrasive paper. This procedure was repeated four more times. A value in the second column, 58 ± 3, for example, is the average number of rotations to destruction and standard error of 5 specimens of fabric No. 1, each tested with a new piece of abrasive paper. A value in the third column, 110 ± 5, for example, is the average number of rotations to destruction and standard error of 5 specimens of fabric No. 1, each tested with a piece of abrasive paper that had already been used for testing a specimen of this fabric. A value in the fourth column, 127 ± 7, for example, is the average number of rotations to destruction and standard error of 5 specimens of fabric No. 1, each tested with a piece of abrasive paper that had already been used for testing 2 specimens of this fabric. The values in the fifth and sixth columns were similarly obtained. In other words, before the fifth specimen of a fabric was tested with a piece of abrasive paper, the piece of abrasive paper had been used for a number of rotations which was equal to the sum of the number of rotations of the first, second, third, and fourth tests. The great decrease in the abrasive power of a piece of this abrasive paper is at once obvious, especially at the beginning of a test with a new piece of abrasive paper, as can be seen by comparing the values in the second and third columns. Because of this great change in the abrasive character of these types of abradants, it is customary to test only one specimen with each piece of abradant. In some work, where a test lasts a long time, the piece of abradant is periodically replaced by a new one or the abradant surface is redressed with a more severe abradant.

Although this procedure may seem best under these conditions, actually the results obtained may be misleading. For example, it would be erroneous to conclude that fabric No. 8 is twice as resistant to abrasion as fabric No. 1. It is clear from the values for fabric No. 1 that after 58 rotations for the first test the abrasive power has dropped to about one-half, so that 110 rotations are required for the second test. A similar change in this abradant is produced for each of the other 16 fabrics. Also, it can be seen from the standard error that the variability of the abrasive power of a piece of abrasive paper increases with use; the standard error for the second test is, on the

average, more than twice as great as that for the first test. The change in the abrasive power of the abradants during a test probably is the primary cause for the erratic results frequently reported in inter-laboratory testing conducted under otherwise similar testing conditions.

The spring steel blade abradant shown in A of Figure 1 has been used for over 1,000,000 rotations on a large number of cotton fabrics. It was found that in these tests the action of the abradant changed less than 3 percent in over 100,000 rotations, which was much less than the variation between specimens taken from any one of these fabrics. For comparative testing of several fabrics this abradant can be considered to remain constant.

It is of interest to report the results of an entirely opposite effect on the abradant which was observed with one fabric. Instead of the usual decrease in the abrasive power of the abradant, in this case the abrasive power was greatly increased—that is, successive specimens were worn to destruction in fewer rotations, as shown in Figure 15. The first specimen tested required over 8,000 rotations and the second one required less than 2,000. After the test on the third specimen the rate of abrasion was nearly constant and about ten times the initial rate. It was found that a resinous substance on the fibers stuck to the surface of the abradant. This substance was thermoplastic and apparently very sticky, so that the frictional force between this substance on the abradant and the fibers of the specimen was many times greater than that between the clean abradant and the specimen and therefore increased the rate of abrasion. The same result was obtained when the pyrex glass rod abradant was used. The appearance of the end of a coated and an uncoated pyrex glass rod is shown in A and B of Figure 16. Although the effect described cannot be ascribed to a faulty operation of the abrasion machine or of the abradant, nevertheless it is apparent that erroneous conclusions can be drawn if the operator of the machine is not an alert and critical observer.

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Use of Probability Paper for Estimating the Mean and Standard Deviation of Normally Distributed Textile Test Data

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PROBABILITY PAPER has been used in the textile field to indicate the skewness of data [6] for presentation purposes. However, it appears that its use for rapidly estimating the mean and standard deviation of normally distributed textile test data has received but little attention [3, 5]. It is proposed to show the use of this paper† as a tool for the rapid and reasonably accurate evaluation of such data, especially when a large number of observations are made. The method is applicable to any set of data which is approximately normal in distribution.

The abscissa of the probability graph paper is a probability scale for plotting the cumulative percentages of the frequency of the data, and the ordinate is linear for plotting the test values. The scale of the abscissa is arranged so that the plot from the data of a true normal or an approximately normal distribution is a straight line.

To illustrate the simplicity of the use of this graph paper, a set of actual data will be analyzed and then a justification will be given for the various steps. Table I gives a set of typical yarn tensile-strength data, taken on an incline-plane tester, arranged in order of magnitude. It will be noted that 24 observations divide the possible range of values into 25 intervals. ("Below the lowest observation" and "above the highest observation" are each considered as an interval.) Each observation therefore represents 4 percent of the total number of intervals. Hence,

$$\text{Percentage value of each observation} = \frac{100}{N+1}, \quad (1)$$

where N = number of observations.

The data in Table I are divided into five groups. The cumulative frequency of each successive group is given in the third column of data. Since each observation of this experiment is worth 4 percent, column 4 of the table follows.

In plotting these data on the probability paper it is not necessary to start the ordinate values at zero. In Figure 1 the ordinate is laid out from 400 to 650 grams. This spread will fit the groups easily and afford better accuracy by not crowding the data. The group "450 or less" has a value of 28 percent. Therefore, a point is plotted at the inter-

TABLE I. TENSILE STRENGTHS OF 17's COTTON YARN, 3.50 T.M.

	Tensile strength (g.)	Group limits (g.)	No. observations in group	Cumulative percentage of observation
1	405			
2	425			
3	430			
4	435			
5	440			
6	443			
7	450	450 or less	7	28
8	460			
9	462			
10	471			
11	499	500 or less	11	44
12	507			
13	512			
14	525			
15	525			
16	530			
17	530			
18	535			
19	545			
20	548	550 or less	20	80
21	575			
22	585			
23	595	600 or less	23	92
24	610			

Calculated results: (Mean) $\bar{x}$ = 501.75 grams.
(Standard deviation) s = 58.8 grams.

* One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

† Keuffel and Esser graph paper No. 358-23 or its equivalent.

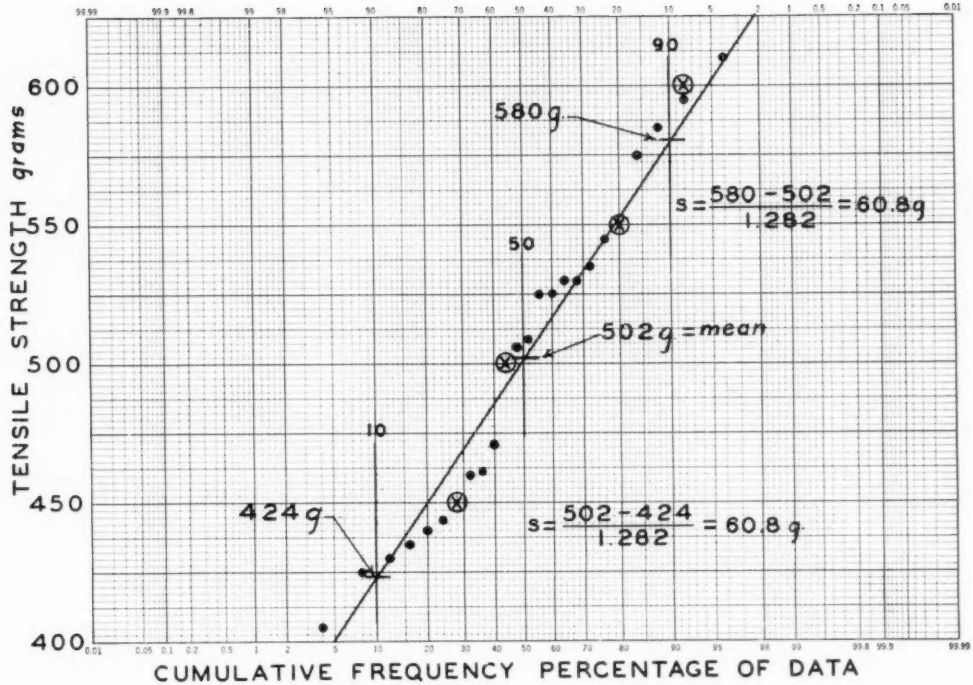

FIG. 1. *Plot of data of Table I on probability paper. (Individual points at 450, 499, and 548 grams not plotted for clarity reasons.)*

cept of 450 grams and 28 percent, and points are similarly plotted for the other values. The plotting of the values for the groups gives the four points surrounded by circles, through which a straight line can be fitted. The fitting of a straight line to the points plotted is slightly different from the usual visual fitting of a curve. Here each point is not of equal weight, since the weight of each point is roughly proportional to the number of observations contributing toward that point. Therefore, extreme points are of lesser weight whether they occur at the upper or at the lower extremities, because such points are determined by a single or by only a very few observations. Consequently, in drawing the line, greater consideration is paid to the points within the range of roughly 10 to 90 percent. The ordinate value of the intersection of this line with the 50-percent ordinate is taken as an approximation to the mean of the population. The standard deviation is then readily computed, as shown in Figure 1, by use of equation (2).

$$s = \frac{\text{Ordinate value at } Z \text{ percent} - \text{Mean}}{K}, \quad (2)$$

where s = standard deviation of sample; Z = abscissa value for ordinate chosen; and K = number of standard deviations—value obtained from Table II for the particular Z value chosen.

The graphical method gives an average tensile strength of 502 grams and a standard deviation of

TABLE II. VALUES TO USE WITH EQUATION (2)

Z% (Abscissa value)	K (No. of standard deviations)
10.00 or 90.00	1.282
1.00 or 99.00	2.327
0.10 or 99.90	3.091
0.01 or 99.99	3.720

60.8 grams, which is in good agreement with the calculated values of 501.7 grams and 58.8 grams for the example, respectively.

This graphical method of computation has been used in the Textile Testing Section of this Laboratory when a relatively large number of determinations were made and machine calculations would have been time-consuming. Checks run against calculated results showed excellent agreement in all cases. Table III gives some typical comparisons. The method has been used with equal satisfaction by different operators. Its chief merits are simplicity and speed. The saving of time becomes outstanding when it is used for the determination of standard deviations of large samples. A further saving of time is accomplished if the testing machine gives the data already ranked, as in the case of incline-plane testers. It is cautioned that the method loses accuracy when applied to small samples.

In practice it has been found that four or five points are sufficient to define the straight line and that its slope and position are not materially changed by using additional points. To illustrate this, the cumulative percent of the frequency for each observation given in Table I is plotted. It will be noted that the same straight line applies equally well to either set of plotted points.

The use of the probability paper is the application of the normal distribution curve [1] in the following form:

$$\Phi(y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{y} e^{-y^2/2} dy, \qquad (3)$$

where

$$y = \frac{x - \mu}{\sigma}; \qquad (4)$$

x = observed value; μ = mean of the population; and σ = standard deviation of the population.

However, as the "true" population values are usually not known, the experiment is conducted in order to approximate them. Therefore:

$$y = \frac{x - \bar{x}}{s}, \qquad (5)$$

where $\bar{x}$ = mean of the sample and s = standard deviation of the sample.

A point plotted on the graph at the intersection of 400 grams and 20 percent indicates that 20 percent of the sample has a value of 400 grams or less irrespective of how much less. Therefore, the lower limit on the probability integral is $-\infty$. This use of the method corresponds to using equation (3) with y defined as in equation (5). This is the so-called "single-tail" probability integral, which appears to be more popular in foreign literature than in our own.

The expression $\Phi(y)$ has been normalized so that:

$$\Phi(y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} e^{-y^2/2} dy = 1. \qquad (6)$$

An observed value equal to the mean is chosen and substituted in equation (5):

$$x = \bar{x} \quad \therefore y = 0.$$

From a table of the normal distribution function, Table I of Cramér [1], it is found that:

$$\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{0} e^{-y^2/2} dy = 0.500 = 50 \text{ percent}. \qquad (7)$$

Therefore, the ordinate value of the intersection of the regression line and the ordinate for the 50-percent abscissa value will be the mean.

TABLE III. COMPARISON OF CALCULATED AND GRAPHICALLY DETERMINED RESULTS FOR SINGLES COTTON YARN

No. of observations	Mean tensile strength (g.)		Standard deviation (g.)	
	Calculated	Graphical	Calculated	Graphical
49	379	378	34.8	32.9
49	359	361	29.8	29.8
49	359	363	33.0	29.6
49	387	387	31.5	29.8
49	354	349	31.3	31.8
49	402	406	27.2	29.2
24	250	251	23.4	24.8
24	248	248	23.8	25.1
24	237	238	31.2	31.1
50	138	136	25.0	23.4
50	129	129	16.5	16.7
50	124	125	20.1	19.4
49	408	407	36.4	35.9
50	385	383	31.6	32.0
24	118	119	9.6	9.9
24	211	210	18.4	17.6
25	158	159	23.1	23.2
25	155	153	21.2	22.8
50	157	156	22.0	21.8
50	207	207	31.7	32.6
25	200	199	30.9	31.9
25	213	215	31.8	33.5
50	282	281	35.6	35.0
50	287	287	37.2	36.1
50	295	297	40.3	41.9

Now a value x is assumed so that it is one standard deviation greater than the mean. Thus, substituting $\bar{x} + s$ for x in equation (5):

$$y = \frac{\bar{x} + s - \bar{x}}{s} = 1. \quad (8)$$

Again from the table of Cramér [1]:

$$\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{1} e^{-y^2/2} dy = 0.8413 = 84.13 \text{ percent}, \quad (9)$$

or 84.13 percent of normal data is less than $\bar{x} + s$. Consequently, the difference between the 50-percent intercept and the 84.13-percent intercept will be the standard deviation. However, this is a rather inconvenient value to read from the graph. Furthermore, for the greatest accuracy, when taking the difference of two values it is desirable to have as large a difference as possible. Equation (2) and Table II were arrived at to facilitate the computations. The table in Cramér [1], although made up for the proper limits, is not sufficiently complete and hence the larger Federal Works Agency table [4] had to be used. The limits were somewhat different and adjustment accordingly was made to conform to the ones desired.

Although the data are separated into a few large groups, the fitting in of the regression line effectively destroys this grouping and there is no justification to apply Sheppard's corrections [2].

It can be seen from Figure 1 that the line might have been drawn with a somewhat different slope and still appear to fit the points properly. But although different slopes might be proposed, in this instance the mean would still be within approximately ±1 percent of the calculated value. Thus, the mean is not very sensitive to the slope of the regression line. The variation in the slope, on the other hand, will make a considerable difference in the determination of the standard deviation. However, the probable error in the standard deviation [2] is:

$$\pm \frac{0.674s}{\sqrt{2N}}. \quad (10)$$

For the example given, $N = 24$. Therefore, with these data any determination of the standard deviation has a *probable* error of ±9.7 percent. As the number of observations increases, the precision of determination of the standard deviation increases. In the graphical analysis of a larger sample this would be manifest by the points defining the regression line with greater accuracy. In other words, as the size of the sample increases the plotted points will lie more and more closely to the straight line, provided that the population is normal. Deviations from the straight line will be evidence of skew in the case of a large sample. No attempt was made for this report to calculate skew quantitatively.

Acknowledgment

The suggested use of probability paper by L. A. Fiori and the assistance of W. S. Lewis, H. P. Pastor, W. F. McSherry, and Donald Mitcham are gratefully acknowledged.

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Laboratory Techniques

A Comparison of Fiber Tensile Values Obtained on the Pressley Tester and Scott IP-4 at Different Test Speeds*

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Abstract

A comparison was made of fiber tensile values obtained on the Scott IP-4 machine and the Pressley Tester at their normal test speeds and also at comparable test speeds. The effect of elapsed time to break on the strength of fibrous materials was shown to be very great at the test speeds normally used on the Pressley Tester as compared to those on the Scott IP-4 machine.

IN A PREVIOUS ARTICLE [8] a test method was described which makes it possible to test cotton fiber strength at a constant rate of loading comparable to that used for yarn and cords. Tensile data reported in the previous article were confined to values obtained on the Scott IP-4 machine at various fiber jaw spacings. No comparison was made between the Scott machine and the Pressley Tester. Because the Pressley Tester operates at a test speed approximately eleven times faster than that chosen for the Scott IP-4, it became imperative that tensile values obtained on the two machines be compared. It was assumed that any differences between tensile values obtained on the two machines might be attributed largely to differences in test speeds.

The effect of test speed or rate of loading on the apparent strength of textile materials has attracted the attention of several workers in the past. All workers agree that there is a substantial increase in apparent strength as the test speed is increased. Increases in apparent strength as test speed increased have been reported on single cotton fibers [4, 5], cotton yarn [6, 7], viscose yarn [1], and balloon fabric [3]. Mann and Peirce [4] reported an increase in strength of approximately 10 percent when the rate of loading was increased ten times. This was substantiated by Meredith [5] and Grant and Morlier [2]. However, most investigators agree that the relationship of rate of loading to tensile strength is not linear. It has also been reported that all cotton varieties do not vary to the same degree [4].

It was the purpose of the present study to compare tensile values obtained on the Scott and Pressley machines when operated at their respective normal speeds and also at the same test speed. A study was also made of the relationship of strength to test speed employing a range of speeds between those of the normal Scott and Pressley machines. The Pressley jaws were used for all tests on both machines.

Apparatus and Procedure

The special apparatus needed for mounting the Pressley jaws on the Scott IP-4 machine was described in detail in the previous article [8]. A 20-pound carriage was used on the Scott machine in the current studies for comparison with the Pressley Tester. Tensile breaks occurring within the 10- to 20-pound zone only were recorded.

All tests on the Pressley Tester at normal speed were made in the conventional manner. Pressley tests at below normal speed were accomplished by controlling the speed of the rolling weight. A short length of small-gage nylon monofilament was attached to the top of the rolling weight and threaded over a small pulley in line with and to the left of the Pressley Tester. A 60-gram dead weight was attached to the end of this monofilament and allowed to hang

* This study is closely related to an earlier one by the same author, "A Modification of the Flat-Bundle Test Method for Testing Cotton-Fiber Strength," which appeared in this department in the November, 1948, issue, page 684.

TABLE I. A COMPARISON OF THE SCOTT IP-4 WITH THE PRESSLEY TESTER WHEN USED TO TEST TENSILE STRENGTH OF FIBROUS MATERIALS AT THEIR RESPECTIVE NORMAL TEST SPEEDS

Sample	Scott (normal) Sample mean (G/D)	Scott (normal) Standard deviation*	Pressley (normal) Sample mean (G/D)	Pressley (normal) Standard deviation*	Difference between two sample means	Variability of difference between two sample means†
Cotton (1)	3.59	0.092	4.21	0.109	0.62	0.045
Cotton (2)	3.71	0.125	4.00	0.121	0.29	0.055
Cotton (3)	3.80	0.071	4.23	0.079	0.43	0.035
Staple rayon	3.10	0.082	3.66	0.101	0.56	0.041
Ramie	5.21	0.238	5.86	0.246	0.65	0.109

* Calculation based on small-sample theory.

† S.D. $M_s - M_p = \sqrt{\text{S.D.}^2 M_s + \text{S.D.}^2 M_p}$.

free over the end of the work table. The purpose of the small weight was to overcome inertia and friction of the rolling weight as it moved slowly along the Pressley track. Another nylon monofilament was attached to the same point on the rolling weight and mounted over a pulley in line with and to the right of the Pressley machine and onto a threaded $\frac{3}{8}$-inch rod carrying a 5-inch pulley. The two guide pulleys to the left and right of the machine and the threaded rod and 5-inch pulley were mounted so that the nylon monofilament produced the same angle of inclination as that of the Pressley beam. Figure 1 shows the attachment of the monofilament to the rolling weight and the position of the guide pulleys. The monofilament leading to the threaded rod was wound several times around the rod with one strand in each thread. This comprised the let-off mechanism and allowed the rolling weight to move along the track at a slow and constant rate as a result of the slight tension being applied by the dead weight. The speed of the let-off was controlled by a small laboratory air-stirrer mounted in such a manner that the tapered stirrer shaft made contact with the side of the 5-inch pulley. The side of the pulley was coated with a thin film of rubber cement to produce greater friction and assure instantaneous starting when contact was made. By adjusting the flow of air and changing the angle of contact of the stirrer shaft against the pulley, a wide range of speeds was possible. The air-stirrer was mounted on a ring stand by means of a swivel clamp. When the tension screw of the swivel clamp was released, the weight of the stirrer head caused the stirrer, now in motion, to swing around and downward to engage the 5-inch pulley. This produced instantaneous starting of the let-off mechanism. The rolling weight was stopped by the breaking action of the machine when the break occurred, as in the normal operation.

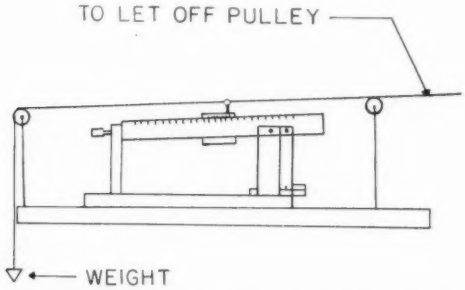

FIG. 1. *Diagram of attachment of speed control apparatus to Pressley Tester.*

The machine test speeds are reported as the total elapsed time required to load from zero load to 20 pounds load. This applies to both machines. The normal test speed for the Scott IP-4 was $22\frac{1}{2}$ seconds, while that for the Pressley Tester was approximately 2 seconds.

Each experimental group of tests represents 10 tensile breaks at the conventional zero jaw spacing used for the flat bundle.

The preparation of samples, technique in handling, etc., were described in the earlier paper [8].

Results

All tensile values are reported as grams per denier (G/D) on the fiber bundle.

Table I presents a comparison of tensile values obtained on the Scott IP-4 with those on the Pressley Tester when both machines were operated at their respective normal speeds. An approximate estimation of the significance of the difference between the two machines was made according to Richardson [9].

TABLE II. A COMPARISON OF THE SCOTT IP-4 WITH THE PRESSLEY TESTER WHEN USED TO TEST TENSILE STRENGTH OF FIBROUS MATERIALS AT THE SAME TEST SPEED

Sample	Scott: Sample mean (G/D)	Scott: Standard deviation*	Pressley: Sample mean (G/D)	Pressley: Standard deviation*	Difference between two sample means	Variability of difference between two sample means†
Cotton (1)	3.59	0.092	3.62	0.079	0.03	0.038
Cotton (2)	3.71	0.125	3.57	0.099	0.14	0.051
Cotton (3)	3.80	0.071	3.68	0.090	0.12	0.038
Staple rayon	3.10	0.082	3.08	0.119	0.02	0.046
Ramie	5.21	0.238	5.17	0.398	0.04	0.146

* Calculation based on small-sample theory.

† S.D. $M_s - M_p = \sqrt{\text{S.D.}^2 M_s + \text{S.D.}^2 M_p}$.

This was done by comparing the difference between the sample means with the product of three times the variability of difference between the two sample means. This test revealed that, in every case, the difference between the sample means was greater than three times the variability of difference between the sample means and that the difference between the samples or machines was significant. Expressed on a percentage basis, the Pressley Tester gave average tensile values 12 percent higher than the Scott IP-4 on cotton, 18 percent higher on staple rayon, and 12 percent higher on ramie.

A similar comparison was made between the two machines when they were operated at the same test speed. Data are given in Table II. Both machines were operated at a $22\frac{1}{2}$-second loading time from zero to 20 pounds load. By applying the same method of approximating the significant difference described above it became apparent that in general the difference between the sample means was not real and that the two machines, when operated at comparable test speeds, gave comparable tensile values.

To study further the effect of test speed on the apparent tensile strength of fibrous materials, samples of cotton and staple rayon were tested on the Pressley Tester at five different test speeds. These were $22\frac{1}{2}$, 12, 6, and $3\frac{1}{2}$ seconds elapsed time to load up to 20 pounds load. In addition, tests were made at the normal Pressley speed. The elapsed time to break for each individual test in all of the speed ranges was calculated. These values were used to plot the curves shown in Figure 2. This method

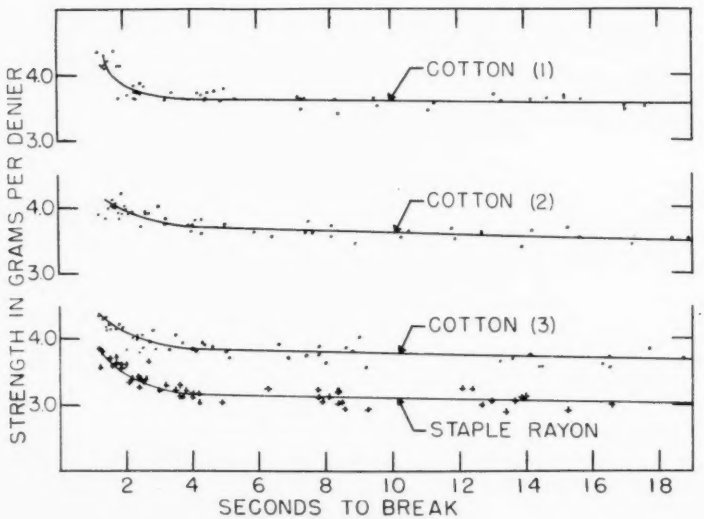

FIG. 2. *Curves showing effect of elapsed time to break on tensile strength of fibrous materials.*

of calculating the elapsed time to break of each test within a given speed range or machine setting produced a greater number of points for plotting and should produce a more reliable measure of the relationship between strength and test speed than if all tests within a machine setting were grouped under one test speed.

Discussion

The tensile data presented in Tables I and II show that the differences between tensile values obtained on the Scott HP-4 and Pressley Tester at their respective normal speeds are due primarily to differences between test speeds of the two machines. At normal operating speeds, the Pressley Tester is approximately eleven times faster than the Scott machine. However, when both were operated at the same speed, comparable tensile values were obtained.

In general, the tensile curves, when plotted against elapsed time to break (Figure 2), show somewhat higher ratios of increase of strength to increase of test speed than those suggested earlier [4, 5]. Previous workers reported 10 percent increases in strength when the test speed was increased ten times. However, the curves in Figure 2 reveal a drastic change in this ratio over the range of speeds used. From $22\frac{1}{2}$ seconds to approximately 4 seconds elapsed time to break the tensile curve becomes a straight line. Within this speed range, the ratio of strength to test speed is somewhat less than 10:10. But from 4 seconds elapsed time to the highest speeds employed the curve changes very abruptly, producing a higher ratio. The ratio of increase of strength to increase of test speed in this portion of the curve is approximately 13:3; that is, the strength increased 13 percent as the test speed was increased three times.

It is now clear that the Pressley Tester normally operates at a very critical speed, as shown by the rapid change in tensile values near the 2-second elapsed-time zone in Figure 2.

It was shown earlier [8] that the use of zero fiber jaw spacings, as on the Pressley Tester, gave tensile values for cotton fiber which fell on an extremely steep portion of the tensile curve.

With this test machine operating at critical points on two highly significant variables, it becomes extremely difficult to correlate cotton fiber strength with the strengths of its end-products which are tested at other points on these curves.

Acknowledgment

The author wishes to express his thanks to Mr. G. D. Mallory of this laboratory for his many helpful suggestions, and to Mr. J. W. Clegg for supplying the cotton samples used in this investigation.

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INDUSTRIAL SECTION

Easier Grade Determination by Measurement in Wool Top

F. M. Wadley,* Elroy M. Pohle,* and Werner A. Mueller*

This paper is a discussion on the determination of the grade of wool top using sequential sampling, thereby minimizing the sample sizes. Industrial firms conducting fineness testing and wool-grade variability determination will be interested in this presentation and approach, which is suggestive of considerable time-saving analysis.—Editor

STANDARDS for fiber diameter in grades of wool top have been set up and published [1, 2, 3, 7, 8]. They are based on microscopic measurements of fiber diameter, which are set up in grades in a numerical range sufficient to fix the average diameter of the lot within narrow limits. The limits of average diameter and the number of fibers required, as prescribed for each grade, are shown in Table I.

Standards as now set up are aimed at estimating the mean diameter for a lot, with a standard error of about 0.2 micron. The standard deviation of individual measurements varies through the range. For fine wool it is about 4 microns; for the coarsest grades, over 8 microns. The number prescribed for measurement varies accordingly, from 400 to 1,600.

Approach to the Problem

The object in most diameter measurements is to find the grade within which a given lot falls and to be reasonably sure that it is within the limits. This is a different matter from determining the lot mean closely. The latter objective would call for measurement of a fixed sample number. The objective of fixing the grade within specified limits would not necessarily call for a measurement of a fixed number; in some cases more measurements are needed than in others. If the measurements place the average diameter near the middle of the grade, the standard error is such that even with a small sample the assertion can be made with reasonable confidence that the lot is within the limits. If the lot mean is near the outer limits or border of a grade, a much larger number of fiber measurements are needed for such confidence. This concept opens the way to some modification of the long and tedious work required in measuring.

In developing the modification, an effort is made to specify the number of fibers which will give confidence (at the 95% level) that the lot value is distinct from the first value specified in the adjacent grade. The values are stated in tenths of a micron (Table I). Investigators are usually concerned about variation only in one direction in a given test. "One-tail odds" are appropriate; for 95% confidence the standard error is multiplied by 1.65 instead of by the usual 1.96 or 2 [5] because the distribution of possible

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TABLE I. CONFIDENCE LIMITS FOR SAMPLES OF GIVEN SIZE

Grade	Prescribed Limits (microns)	No. of fibers to measurement	Confidence limits for given number of fibers: 100	200	300	400	600	800	1,000	1,200	1,600
80's	18.1	400	18.55	18.39	18.32	18.28	18.23	18.20	18.18	18.16	18.14
	19.5		18.94	19.13	19.21	19.27	19.33	19.37	19.39	19.41	19.43
70's	19.6	400	20.16	19.96	19.88	19.83	19.77	19.73	19.71	19.69	19.66
	21.0		20.34	20.57	20.66	20.71	20.79	20.83	20.86	20.88	20.91
64's	21.1	600	21.75	21.53	21.43	21.38	21.31	21.27	21.24	21.22	21.19
	22.5		21.76	22.00	22.11	22.18	22.26	22.30	22.33	22.36	22.39
62's	22.6	600	—**	23.09	22.98	22.92	22.84	22.80	22.76	22.74	22.71
	24.0		—	23.45	23.56	23.64	23.72	23.77	23.81	23.83	23.87
60's	24.1	800	—	24.65	24.53	24.46	24.38	24.32	24.29	24.27	24.23
	25.5		—	24.89	25.02	25.10	25.19	25.25	25.28	25.31	25.35
58's	25.6	800	—	26.21	26.08	26.00	25.91	25.85	25.82	25.79	25.75
	27.0		—	26.34	26.48	26.56	26.66	26.72	26.76	26.79	26.83
56's	27.1	1,200	—	27.76	27.62	27.54	27.44	27.38	27.34	27.31	27.27
	29.0		—	28.28	28.43	28.52	28.63	28.69	28.73	28.76	28.81
50's	29.1	1,200	30.16†	29.82	29.67	29.58	29.47	29.41	29.37	29.34	29.29
	31.5		30.33	30.70	30.87	30.96	31.08	31.15	31.20	31.23	31.28
48's*	31.6	1,600	—	—	32.23	32.13	32.01	31.95	31.90	31.86	31.82
	33.2		—	—	32.53	32.64	32.76	32.83	32.88	32.92	32.97
46's	33.3	1,600	—	—	33.97	33.86	33.74	33.67	33.62	33.58	33.53
	34.7		—	—	34.00	34.10	34.23	34.31	34.36	34.40	34.45
44's	34.8	1,600	—	—	35.50	35.40	35.27	35.19	35.14	35.10	35.05
	36.5		—	—	35.76	35.87	36.00	36.08	36.14	36.18	36.24
40's	36.6	1,600	—	37.53	37.34	37.22	37.09	37.01	36.96	36.92	36.86
	38.7		—	37.72	37.92	38.04	38.18	38.26	38.32	38.36	38.42
36's	38.8	1,600	—	39.78	39.58	39.46	39.32	39.24	39.18	39.14	39.08
	41.3		—	40.26	40.47	40.60	40.74	40.83	40.89	40.93	41.00

* For 48's and coarser grades, values are according to A.S.T.M. [2].
** Dash indicates that no sample of this size could give required confidence.
† Values near mid-point give evidence of 50's with only 100 fibers because of wider limits.

samples around a true mean in the edge of the adjacent grade is to include only the extreme 5% in one tail as distant as our sample mean. The sample mean is then judged unlikely to have come from the nearest value in the adjacent grade.

For example, with 70's the grade limits are 19.6 and 21.0 microns, the mid-point, 20.3 microns. The standard deviation is estimated as about 4.0 for the coarsest 80's diameter limit, and about 4.6 for the finest 64's diameter limit. If 100 fibers are taken, the standard errors based on these will be 0.40 and 0.46; when multiplied by 1.65, these are 0.66 and 0.76, respectively. If the first 100 fibers measured average between 20.16 and 20.34 microns, this is satisfactory evidence that the top is of grade 70's. The coarsest value in 80's is 19.5 microns. A sample of 100 fibers averaging above 20.16 microns would hardly come from a lot averaging 19.5, since 19.5 is 0.66 micron less than 20.16. (This implies a total range of 1.32. A sample of 100 with mean 19.5 microns might perhaps vary from 18.84 to 20.16 microns, but not likely above 20.16 microns.) Likewise, a lot averaging 21.1 would not be expected to yield a sample of 100 measurements averaging less than 20.34 microns. Probabilities are much smaller for more distant values. The same line of reasoning may be extended, with successive hundreds, as the standard error grows smaller with increased numbers. As another example, with a sample apparently 56's; for 58's, the coarsest specified value is 27.0 microns. From the standard deviation usually encountered, a lot with a mean of 27.0 microns might yield samples of 200 fibers averaging from 26.24 to 27.76 microns, but not likely coarser than 27.76 microns. The same concept will apply toward 50's. If the sample of 200 fibers averages between 27.76 and 28.28 microns, it may be placed in 56's.

Hence, if the first 100 fibers average between 20.16 and 20.34 microns, further work might be omitted, and the top placed as 70's. If the average is within the limits of 70's, but outside 20.16–20.34 microns, another 100 fiber measurements should be taken. If the first *200* fibers average between about 20.0 and 20.6 microns (see Table I), this is satisfactory and the

TABLE II. SUGGESTED MAXIMUM STANDARD DEVIATIONS FOR EACH GRADE

Grade	80's	70's	64's	62's	60's	58's	56's	50's	48's	46's	44's	40's	36's
Standard deviation maximum (microns)	4.4	5.0	5.5	6.0	6.4	6.9	7.4	8.1	8.5	8.8	9.2	9.7	10.2

top may be considered as 70's; if they average outside these limits, another 100 fibers should be measured. If the first 300 fibers average between 19.9 and 20.7, acceptance may follow; otherwise, a fourth 100 should be measured. The 400 should give confidence if they average between 19.8 and 20.7 microns; if the average is outside these limits even greater numbers would be needed for much confidence. However, even if the sample is of the border-line type, the standard error of 0.2 and the multiplier 1.65 indicate confidence that the lot is not over about 0.3 micron into the adjacent grade. The prescribed number, therefore, might be taken as a maximum. The use of these concepts must rest on satisfactory estimates of standard deviation and control of sampling and measuring variation. In some cases greater variation than assumed above will occur. This may be due to lack of control of technique. Such control, with either the present plan or the suggested modification in Table I, must be secured, or no fiber number can be specified for successful results.

Outline of Confidence Limits

These considerations have been drawn together for the 13 grades of wool top. Table I presents the number of fibers necessary for confidence with various sample mean-diameter values. Standard deviation estimates have been drawn from the best available sources in the Wool Division standardization records. As noted, standard deviation increases rather regularly with mean diameter. Standard deviation is quite evidently proportional to diameter and has a linear relationship with the logarithm of diameter. In the experience of the senior writer and other biometricians, this condition is common in widely varying measurement data of this kind. It is touched upon by W. G. Cochran [4] and others. As interpolation is necessary to obtain standard deviation estimates for the end values of the grades, a curve was fitted. The equation for the curve is: Standard deviation = 17.72 log diameter − 18.87. For example, for 80's, it is desired to estimate the probability of getting a certain value from a fine-diameter 70's (19.6 microns). The log of 19.6 is 1.292: (1.292 × 17.72) − 18.87 gives 4.02; the standard deviation estimated for a mean diameter of 19.6 microns is thus 4.0. This equation gives a smooth series of values closely agreeing with sample estimates. Standard deviation estimates for calculating Table I have been made from this curve.

Frequency Distributions

Although this discussion is concerned primarily with average diameter, the frequency distribution of individual fiber diameters will be discussed parenthetically. This distribution is also considered in grading [7, 8]. The standard specifications fix minimum percentages of fibers below certain diameters, and maximum permissible percentages of coarse fibers.

These requirements offer considerable difficulty in classification, especially with the low maximum percentages based on a limited sample. A case recently noted was of a lot otherwise acceptable, graded down because 19 coarse fibers occurred in the sample where only 16 (2% of 800) were allowable. The distribution of these limited numbers in successive samples must approximate the "Poisson," and 19 or more might often occur in a sample (about 18% of the time) where the true lot value is 15 [6]. Other similar situations might be cited. It is evident that the provision for low maximum percentages results in occasional condemnation of some lots that otherwise could be accepted, and vice versa.

It seems possible that if fairly good estimates of mean and standard deviations are available, they might sufficiently indicate the frequency distribution. Fiber distribution in wool top may be expected to be fairly definite, although it may not be quite "normal." Even with distributions differing a little from the normal, the standard deviation will reflect greater variation, such as that caused by several coarse fibers in a fine lot. The standard deviation as a criterion has been already suggested [1].

It is hoped that some easing of frequency distribution requirements may eventually be worked out. It seems possible that a maximum allowable sample standard deviation might be stated for each grade, as a substitute for the rather difficult determination of extremes of distribution. Such a standard devia-

TABLE III. RESULTS OF EXPERIMENTAL SAMPLING TO TEST CONFIDENCE LIMITS OF TABLE I

Grade	Range (microns)	Lot mean	Total no. of fibers	No. of samples	No. showing shortened work	No. of wrong placements	Average no. of hundreds	No. of hundreds prescribed
80's	18.1–19.5	19.3	2,200	20	12	0	2.9	4
60's	24.1–25.5	25.0	1,800	20	19	0	4.2	8
50's	29.1–31.5	30.3	2,400	20	20	0	2.6	12
46's	33.3–34.7	33.7	3,600	20	16	0	9.8	16

tion should be the expected value for the largest diameter of the grade, increased by about 2 standard errors. The specified numbers and usual standard deviations lead to a general value of about 0.15 micron for standard errors of the standard deviation. Values for smaller samples resulting from data in Table I might increase this to about 0.20, and the addition to the expected standard deviation might thus be 0.4.

Lots showing higher values than those given in Table II would be dealt with as being too high in dispersion for the grade. Preliminary examination of a number of sets of data confirms the idea that typical lots have standard deviations lower than these limits; and lots with too many coarse fibers tend to have higher standard deviations. While the mean diameter is undoubtedly the principal criterion, the standard deviation may prove a good supplementary one, and may be of assistance when determination of frequency distribution is difficult.

Practical Tests of Confidence Limits

Some of the work of measuring fibers has resulted in recording fiber diameter in many consecutive hundreds from the same lot. These records offer a chance to test the procedure outlined, using limits given in Table I.

The modification offers relief from part of the work in some cases. The only attendant risk is that of placing a lot incorrectly; for example, of calling a lot low 80's when it is really 70's. The limits set out in Table I are based on 95% protection against such a mistake if the true value is in the border of the adjacent grade. The protection is much higher against a mistake if the true value is nearer the center of the grade range. For instance, if the first 100 fibers average between about 18.6 and 18.9 microns, they are classed as 80's; there is only a 5% probability that a fine 70's (19.6 microns average) would give such a sample. The probability is very much less than 5% of getting such a sample from medium (20.3 microns) or coarse (say 20.8 microns) 70's. On the whole, the possibility is very small that any 70's lot would give a sample of 100 fibers averaging between 18.6 and 18.9. With the other confidence limits, the case is similar; the risk of wrong placement seems very small. Putting it another way—while a single sample of 100 or 200 fibers might stray rather far from its lot mean, there is small chance of its fulfilling the exacting requirements for placement in another grade.

The chance of gain and the risk of mistake have been tried out on some of the lots mentioned. In the first trial, the 11 grades measured were studied, taking consecutive hundreds from the start. In 9 of the 11 cases some saving was obtained; in all, the work was reduced about one-half. No approach to wrong determination was noted. A more comprehensive trial was arranged, using lots of both finer and coarser grades. Some lots were near the middle and others near the edge of the grade range. In each, a large total number, enough to estimate the true mean closely, was available. Individual hundreds were taken in random order to form a number of samples from each. Table III presents the results.

Eight samples of Table III were not positively determined by Table I when the prescribed maximum number was reached; 4 were within the proper grade limits, 2 on the border, and 2 in the edge of an adjoining grade. The last two did not meet the requirements for placement in the adjoining grade. The sampling was not carried farther after reaching the maximum number prescribed. No tendency to error in placement occurred that would not also have occurred with the specified number.

While this test was on a rather restricted set of material, it confirms strongly the theory used in Table I. The reduction in work was over 50% on the whole. It is noted that saving is greatest where the lot is near the middle of the grade range. Only 3 samples of the 80 taken even approached a wrong classification in the course of the sampling.

Occasional counts on newer lots have also been encouraging.

It is believed this approach will make possible more rapid work in determining the grade of wool top.

Acknowledgment

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Repeatability and Tolerances of Laboratory Spinning Techniques*

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IN SETTING UP and operating a spinning laboratory, a number of bench marks must first be established. Among the most important of these are: (1) size of test necessary for reliable results; and (2) repeatability or experimental error. If the first item is not established, results may be accepted on insufficient data; or, vice versa, time may be wasted in running tests longer than necessary. If the second yardstick is not determined, it is impossible to interpret that data accurately, since it would not be known when to attach significance to test results. In order to settle these questions, therefore, two series of tests were conducted, in each of which the cotton mix was held constant, and the manufacturing was performed with as nearly identical conditions as possible.

Procedure

The fiber and manufacturing tests were conducted in the cooperative fiber and spinning laboratory of the Texas Technological College and the Research Division of the Chicopee Manufacturing Corporation at Lubbock, Texas. All fiber tests were conducted under controlled atmospheric conditions of 70°F and 65 percent R.H. Beginning with the opening and through the roving process, a relative humidity of approximately 50 percent was maintained, with no attempt to control the temperature. The spinning was performed under approximately 60 percent R.H. and the temperature was regulated by evaporative coolers so that it did not exceed 85°F in summer.

The first series of tests was performed on 6 bales of unknown variety and growth location, classed as strict low middling and low middling, $1\frac{1}{32}$-inch. These cottons were carefully blended and then manufactured on standard commercial-type cotton mill machinery. Approximately 275 pounds of lint were used in each of five tests, four of which were run at intervals of one month from March through June, 1946, and the other in October, 1946. The second series of tests was made on a 12-bale mix of one-variety cottons from one location of growth, which were classed as middling and strict low middling, $1\frac{1}{16}$-inch.

Both series were tested in as nearly the same manner as possible, the following procedure being used for all tests.

The bales were opened, and equal amounts of cotton from each were blended in the opener hopper. The cotton then passed through the Aldrich beater, vertical opener, condenser, one-process picker (2-blade beater, and Kirschner carding beater), cards, first-process drawing, second-process drawing, long-draft roving, and long-draft spinning. Moisture tests were made on the raw stock and picker laps. All types of waste obtained, from opening through the carding process, were weighed and the percentages of loss were calculated on the basis of the weight fed. A record of all spinning ends down was kept and each break was classified as mechanical or as caused by the cotton, according to the reason for breaking. The end breakage was then calculated for each side of each of the 6 spinning frames and recorded as ends down per 1,000 spindle hours. Yarn tests were made in order to determine the difference in yarn strength and yarn appearance for the series of tests.

TABLE I. FIBER DATA FOR FIRST SERIES OF REPEATABILITY TESTS

Item	Data
Grade	SLM–LM
Staple	$1\frac{1}{32}$
Fibrograph upper-half mean (in.)	1.02
Fibrograph mean (in.)	.78
Fibrograph uniformity (%)	81
Fiber fineness (wt. per in.—μg.)	4.5
Maturity (%)	76
Fiber strength (1,000 lbs. per sq. in.)	71

* Work conducted under the general direction of George W. Pfeiffenberger, Spinning Research Director of the Chicopee Manufacturing Corporation, Texas Technological College, Lubbock, Texas.

† Textile Engineer, Chicopee Manufacturing Corporation.
‡ Head, Textile Department, Texas Technological College.

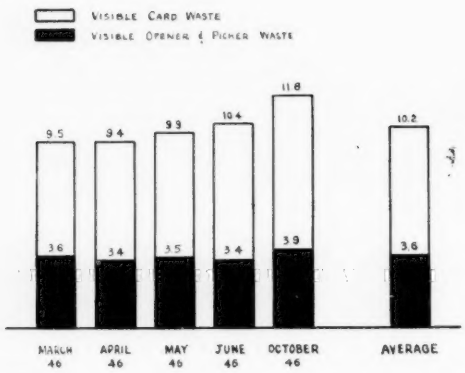

FIG. 1. *Comparison of percent waste losses through the opener, picker, and card of five replicate tests.*

Tables and figures have been prepared showing the main factors of interest—waste, neps, spinning ends down, yarn strength, and yarn appearance. Brief definitions of these are as follows:

1. "Waste" includes trash, dust, seeds, and all foreign matter in the lint. It also includes tangled and wasty fibers which are taken out during the cleaning processes. A low waste loss is desirable for a given grade.

2. "Neps" are small tangled masses of fiber which appear as white specks in the yarn and fabrics, and are therefore undesirable.

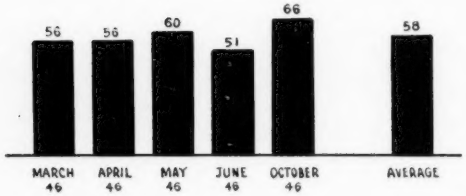

FIG. 2. *Comparison of neps per 100 square inches of card web for five replicate tests.*

3. "Spinning ends down" is a measure of the number of times the yarn breaks for 1,000 spindle hours of operation of the spinning frames. Excessive ends down are costly in processing, so a low number of ends down is desirable.

4. "Yarn strength" is the actual breaking load of a skein of yarn (120 yards wound into a loop $1\frac{1}{2}$ yards in circumference). A weak yarn is undesirable because it lowers both the weaving efficiency and the final quality of the cloth.

5. "Yarn appearance" is a measure of the neppiness and irregularities of the yarn. Grades range from A to D, in the order of decreasing quality. Poor yarn appearance is a detriment to final quality, and is especially undesirable in dyeing.

Results

Table I contains the fiber data for the 6 bales used in the first series. The fibrograph figures represent

TABLE II. WASTE AND SPINNING DATA FOR FIRST SERIES OF REPEATABILITY TESTS (30's WARP YARN)

Item	Mar. '46	Apr. '46	May '46	June '46	Oct. '46	Average
Grade	SLM–LM	SLM–LM	SLM–LM	SLM–LM	SLM–LM	SLM–LM
Staple	$1\frac{1}{32}$	$1\frac{1}{32}$	$1\frac{1}{32}$	$1\frac{1}{32}$	$1\frac{1}{32}$	$1\frac{1}{32}$
Opener waste (%)	2.21	2.12	2.12	2.07	2.19	2.14
Picker waste (%)	1.41	1.23	1.36	1.34	1.69	1.41
Total visible waste (%)	3.62	3.35	3.48	3.41	3.88	3.55
Total invisible waste (%)	−.73	.58	.40	−.30	.75	.14
Net loss (%)	2.89	3.93	3.88	3.11	4.63	3.69
Flat strips (%)	3.43	3.52	3.84	3.95	4.12	3.78
Cylinder and doffer (%)	.54	.70	.78	.98	1.36	.87
Motes and fly (%)	1.92	1.82	1.84	1.99	2.45	2.00
Total visible card waste (%)	5.89	6.04	6.46	6.92	7.93	6.65
Total invisible card waste (%)	−.86	−.70	−1.26	−.48	−1.76	−1.01
Net card loss (%)	5.03	5.34	5.20	6.44	6.17	5.64
Total visible, all types (%)	9.51	9.39	9.94	10.39	11.81	10.20
Net loss, all types (%)	7.92	9.27	9.08	9.55	10.80	9.33
Neps/100 sq. in. card web	58	56	60	51	66	58
Ends down/1,000 spindle hrs.	87.8	51.2	36.8	26.2	22.2	44.8
Spindle hours' run	3,510	4,880	7,230	6,280	4,938	26,838
Yarn strength (lbs. per skein)	62	64	61	62	60	62
Yarn appearance grade	—	B+	B	B+	B	B

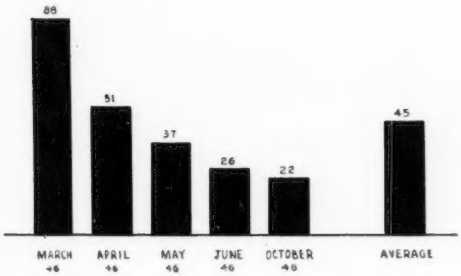

FIG. 3. *Comparison of spinning ends down per 1,000 spindle hours for five replicate tests on 30's warp yarn.*

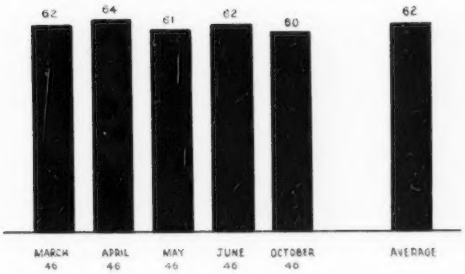

FIG. 4. *Comparison of 30's warp yarn skein strength in pounds for five replicate tests.*

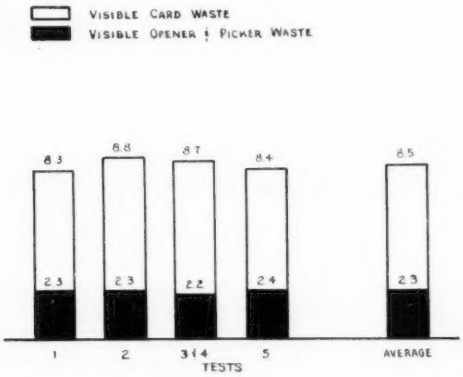

FIG. 5. *Comparison of percent waste losses through the opener, picker, and card for four replicate tests.*

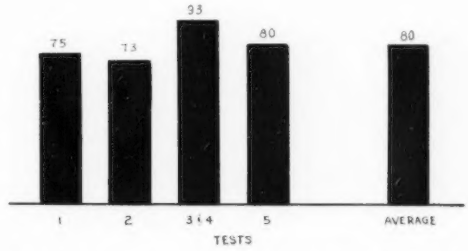

FIG. 6. *Comparison of neps per 100 square inches of card web for four replicate tests.*

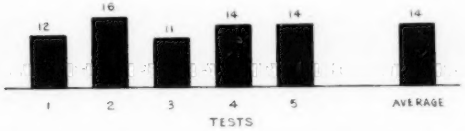

FIG. 7. *Comparison of spinning ends down per 1,000 spindle hours for five replicate tests.*

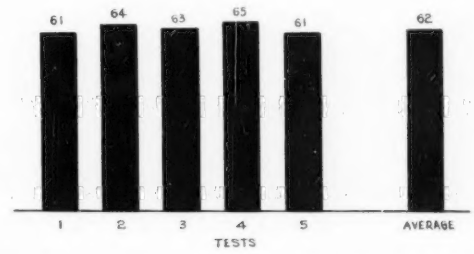

FIG. 8. *Comparison of skein strength in pounds for five replicate tests.*

the average of two curves for each of two combings, or four readings. The upper-half mean shows that the staple length is about $1\frac{1}{32}$ inches, as it was classed by the cotton classer. The fiber is in the medium class of fineness, or 4.5 micrograms per inch. This figure represents two samples with two readings on each, which has been found to be satisfactory, as the repeatability of the permeameter readings is very good. The percent maturity and the fiber strength are both in the medium classification and represent ten readings each.

Waste losses, nep counts, and spinning performance are presented in Table II. Figure 1 is a graphic representation of the percent of total visible opener, picker, and card waste. The repeatability of these tests is very good.

The number of neps per 100 square inches of card web are illustrated in Figure 2. Agreement between the tests is good, as there is a total range of only 15 neps, which is within the degree of significance.

The repeatability of the spinning ends down for 30's warp yarn, as shown in Figure 3, is poor. This

TABLE III. FIBER DATA FOR SECOND SERIES OF REPEATABILITY TESTS

Item	1	2	3	4	5	Average
Grade	25% M 75% SLM	50% M 50% SLM	50% M 50% SLM	50% M 50% SLM	50% M 50% SLM	
Staple	1 1/16	1 1/16	1 1/16	1 1/16	1 1/16	1 1/16
Fibrograph upper-half mean (in.)	1.19	1.15		1.06		1.10
Fibrograph mean (in.)	1.01	.94		.81		.88
Fibrograph uniformity (%)	85	82		76		79
Fiber fineness (wt. per in.—μg.)	4.4	4.6	4.4	4.6	4.7	4.4
Maturity (%)	67	70	74	75	68	71
Fiber strength (lbs. per skein)	67	68	69	70	76	70

can be explained, however, as the first four tests were done during the early months in which the laboratory was being established. This necessitated getting the machinery properly adjusted for speeds and settings, breaking-in of new rings, finding the proper size traveler, etc. Personnel training was also involved. This is evidenced by the amount of drop for the first 4 months, the second test being 37 ends down lower than the first test; then there are drops of 14 and 11, which shows that the ends-down figures were leveling off, owing to better operation. The difference of only 4 ends down between the fourth and fifth tests is negligible and represents good repeatability of end-breakage data. This first series proves that the condition of the machinery greatly affects ends down. For accurate tests, therefore, equipment must be in as nearly perfect and constant condition as possible if the best results are to be obtained. Ends-down testing is very sensitive and small changes in machinery, atmospheric conditions, etc. have a definite effect. Since some factors are almost impossible to control, a sizable number of spindle hours are required to average out these uncontrolled factors.

The yarn strength shown in Figure 4 indicates very good repeatability, as there is only 4 pounds difference per skein for the complete series.

The same is true of yarn appearance, since the one-third of a grade difference in the tests is not significant.

This series of tests gave preliminary bench marks to establish the significance and dependability of the data obtained from the spinning tests. It was felt

TABLE IV. SPINNING PERFORMANCE OF SECOND SERIES OF REPEATABILITY TESTS

Item	1	2	3 and 4	5	Average
Grade	25% M 75% SLM*	50% M 50% SLM	50% M 50% SLM	50% M 50% SLM	
Staple	1 1/16	1 1/16	1 1/16	1 1/16	1 1/16
Opener waste (%)	1.37	1.37	1.27	1.43	1.36
Picker waste (%)	.89	.96	.91	.94	.92
Total visible waste (%)	2.26	2.33	2.18	2.37	2.28
Total invisible waste (%)	−.20	−1.93	.01	.03	−.54
Net loss (%)	2.46	4.26	2.17	2.34	2.82
Flat strips (%)	3.50	3.72	3.92	3.54	3.67
Cylinder and doffer (%)	.98	1.07	1.07	.80	.98
Motes and fly (%)	1.60	1.71	1.51	1.64	1.61
Total visible card waste (%)	6.08	6.50	6.50	5.98	6.26
Total invisible card waste (%)	−1.76	−.15	−.48	−.23	−.54
Net card loss (%)	7.84	6.65	6.98	5.75	6.80
Total visible, all types (%)	8.34	8.83	8.68	8.35	8.54
Net loss, all types (%)	10.30	10.91	9.15	8.09	9.62
Neps/100 sq. in. card web	75	73	93	80	80
Nominal yarn count	30's	30's	30's 30's	30's	30's
Ends down/1,000 spindle hrs.	12.4	16.3	11.4 14.4	13.5	13.6
Spindle hours' run	5,409	5,540	5,157 6,164	4,834	27,104
Yarn strength (lbs. per skein)	61	64	63 65	61	62
Yarn appearance grade	C	B−	C+ C+	B−	C+

* This mix contained 25% more SLM than other mixes in this series.

that the maximum efficiency of the machines was being obtained after the first 4 months, as the ends-down values appeared to be more or less stabilized. This was further verified later when the second series of tests was run to determine the repeatability of spinning performance.

Tables III and IV give detailed data on the second series of repeatability tests. Table III shows quite a difference in fibrograph readings, which may indicate a sampling error. These fibrograph tests were made on lint from the blended laps, and, since the openers and pickers do not break the cotton down into tufts as small as the fibrograph requires, the discrepancies shown here are probably due to not getting a true blended sample in small tufts. The fineness, maturity, and fiber strength readings, however, were all within the experimental error of the tests.

Figures 5, 6, and 8 indicate very uniform data for opener, picker, and card wastes, neps, and yarn strength. The yarn appearance grades were also in good agreement.

The repeatability of the ends-down figures for 30's warp yarn is excellent, as shown in Figure 7. These are very good results, as the maximum range for the series is only 5 ends down per 1,000 spindle hours.

Because of the unexplained temperamental nature of spinning frames, it is necessary to run a test enough spindle hours to balance out the ups and downs. It has been found that under controlled conditions, as in the pilot plant, approximately 5,000 spindle hours for 30's warp yarn is satisfactory. These two series of tests represent approximately 54,000 spindle hours, and should, therefore, give conclusive evidence of the repeatability of the spinning test under controlled conditions.

Conclusions

These two series of experiments indicate that properly conducted spinning tests can be made on different cottons and the results compared directly. Of course care must be taken to see that the machines have proper maintenance, and that the tests are conducted in a uniform manner, so that a good standard of repeatability will be maintained.

In interpreting data from other tests it must be remembered that in order for the differences between cottons to be significant they must be greater than the differences shown in these series, since the differences obtained in this study constitute the experimental error.

Summary

Data from two series of pilot-plant spinning tests, each repeated several times on the same cotton mix, may be summarized as follows:

1. Good repeatability of waste losses at the opening, picking, and carding processes.

2. Good repeatability of nep counts in the card web.

3. Good repeatability of yarn strength and yarn appearance.

4. Good repeatability of end-breakage figures for 30's warp yarn after spinning frames were thoroughly broken-in.

5. Approximately 5,000 spindle hours required for an accurate and significant spinning test on 30's warp yarn.

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Rapid Stroboscopic Study of Production Looms

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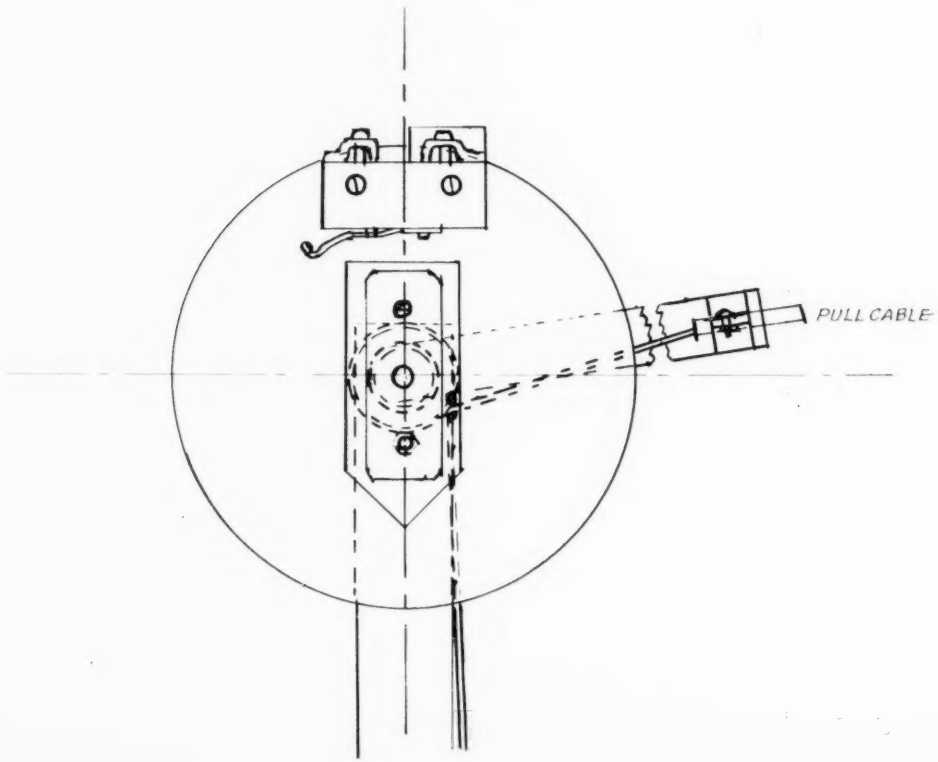
IT IS WELL KNOWN that various stroboscopic means and also high-speed photography have been employed in the study of running looms. These studies, however, have frequently required semidarkness and elaborate accessories not suitable for use in a typical weave room. The goal in this study was to develop a method that would (1) be sufficiently rapid to make it practical to check looms in production in order to correct defects before they could cause stoppages or seconds; (2) be compact and streamlined for minimum interference in the loom aisles; (3) operate in normal mill illumination; and (4) not interfere with the operation of the loom while making the test. From the results of this study it is believed that such a method can be developed.

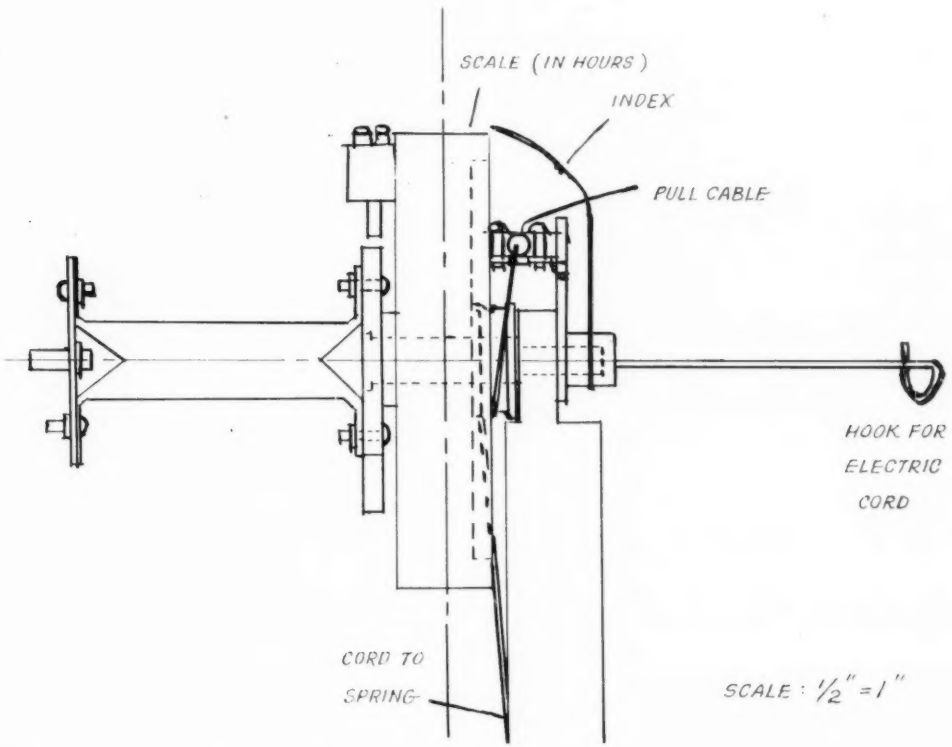
The basic unit required is an Edgerton-type high-intensity flash bulb having sufficient power supply * to produce an exceedingly bright flash each time a

* The lamp used in this study was Type 1532-A Strobo-flash manufactured by General Radio Company.



special circuit is interrupted by a contactor driven in phase with the machine under test. Each flash of light has a duration of only 10 to 15 microseconds so arranged as to make it possible to view any moving part of the loom always at the same position in its cycle. This timing causes the part to appear at rest, with no appreciable blur for relatively fast motion. The illumination is sufficient for taking photographs from single flashes or for the visual study of a large area of the loom at one time without altering the room lighting. To "follow" the motion of any loom part—for example, the shuttle—arrangement is made to advance or retard, with respect to the crankshaft position, the point at which the contact opens, thus causing the shuttle to appear slowly to advance, to recede, or to stop at the operator's command.

In this project the contactor is a microswitch (see Figures 1A and B) to be opened at each revolution by a rotating element directly connected to the crankshaft. This connection is made by means of a hole ¼ inch in diameter bored in the center of the end of the crankshaft (or in the pulley on it), and a second hole ⅛ inch in diameter is bored 1 inch off center in line with the cranks. The rotating element has studs which may be inserted in these holes without stopping the loom. A suitable stand (Figure 2) holds the unit in line with the shaft, and the center stud is rounded on the end and is slightly longer than the off-center pin in order to facilitate insertion of the pins into the holes in the crankshaft while the loom is in motion. A wheel carrying the microswitch is arranged so that it can be revolved about the rotating cam by means of a flexible wire cable and suitable hand control (See Figures 1C and 3) from a position in front of the loom from which the operator observes the action of the loom. The phase of the flash can, at any time, be instantly read from scales placed both on the wheel carrying the contactor and



FIGS. 1A (*page 288*) *and* 1B (*above*). *Variable control mechanism for General Radio Stroboflash 1532-A.*

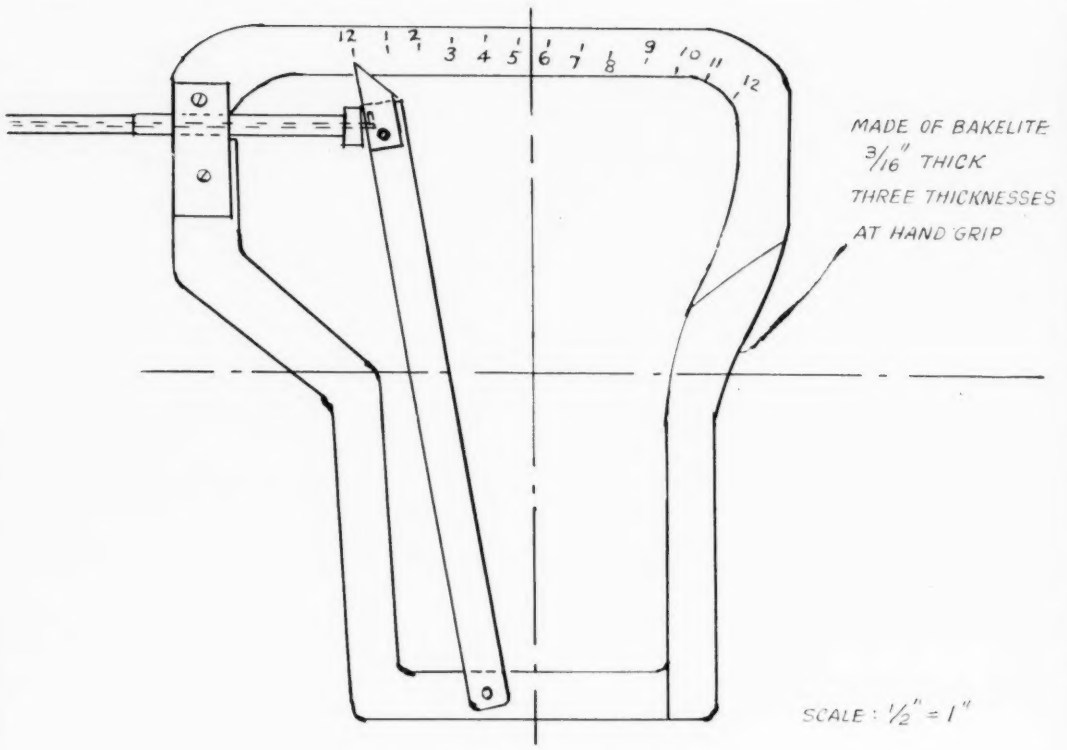


FIG. 1C. *Control for varying time of flash.*

on the phase-shifting handle held in the operator's hand. The scales are graduated in quarter-hour units, from 12:00 o'clock to 12:00 o'clock, as the crank turns one revolution from top-center to top-center again. In terms of this scale, the operator can note for each side of the loom the exact timing of the following:

1. Shuttle starting from box.
2. Forward tip entering shed.
3. Forward tip at center of loom.
4. Forward tip leaving shed.
5. Rear tip leaving shed.
6. Shuttle completely boxing.
7. Harnesses level.

The following readings were taken on a Crompton & Knowles S-5 loom, chosen at random, which was weaving rayon in a near-by mill. The numbers above the readings correspond to the numbered shuttle positions listed.

	1	2	3	4	5	6	7
Battery end pick	12:40	1:30	2:55	5:05	5:50	6:40	6:30
Lever end pick	12:55	1:35	2:55	5:05	5:50	6:40	—

The number of hours past top-center may be reduced to degrees by multiplying by 30.

Several other looms were checked which gave variations of as much as 15 or 20 minutes plus or minus from these readings but averaged approximately the same. A weak picker stick or loose lug strap, which would cause the shuttle to start late, and a tight box, which would cause slow boxing, are revealed by this dynamic timing better than by the fixer's static settings. Looms were found to have a difference of as much as "1 hour" (30 degrees) in the starting time of the shuttle and yet not be "banging off." The pick which has a late starting time

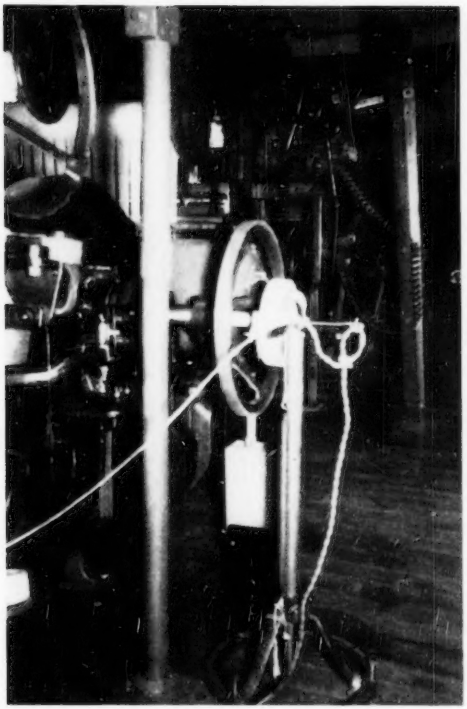


FIG. 2. *Stand supporting basic contactor with rotating element directly connected with crankshaft of loom.*

must be given a correspondingly higher power to get the shuttle across ahead of the protector motion in order to prevent loom stoppage, and this operation is probably expensive in terms of picker sticks, lug straps, shuttles, etc. Checking with this light can be used to correct defective looms in advance of the actual failure of equipment.

All of the above timings, as well as those for box motion, harness motions, etc., can be compared with the static settings made by the fixers. It is believed that records of these timings can be a real aid to the fixers and often can help in locating the causes of fabric defects on bad-acting looms. It is not unusual to find that various timings are actually considerably different from those to be expected from the static timing, owing to variation in picker sticks, lug straps, checks, box tensions, etc. A tolerance on various timings can be established for reporting looms to the

FIG. 3. *Operator in position to observe action of loom.*

fixers before they have actually failed. The shuttle timings can very quickly be determined—certainly in less than 5 minutes per loom. It is contemplated that the unit will be mounted on a small "dolly" (possibly with a self-contained power supply) which will permit the gear to be quickly moved from loom to loom.

In addition to its use for timing purposes, the Stroboflash method is considered to be of outstanding value for critical observational study of the various phases of the weaving operation. This light shows up brilliantly all minute details of any of the loom motions which can be reviewed back and forth by the operator if he opens and closes his grip on the phase-shifting handle as he holds the flash lamp in the correct position in his other hand.

The exact position of the filling yarn, with all its kinks at every point from box to box, can be shown with surprising clarity. Comparisons are readily made on action from the two sides of the loom, or of different boxes on the same side. It is possible that many defects may be detected and corrected that would never be known from normal observation methods before the occurrence of stoppages or seconds.

The apparatus has proved to be easy to use. In several mills the weave-room personnel have been able to make accurate observations the first time they have had the controls and lamp in their hands. It is believed that experienced operators can check the timings at the rate of only 2 or 3 minutes per loom.

This study was made with the helpful cooperation of General Radio Company. Visits to see this equipment and questions concerning its operation at Clemson are invited.

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Universal Yarn Numbering Systems

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American Society for Testing Materials, Committee D-13 on Textiles, Subcommittee B-2 on Definitions

UNIVERSAL YARN NUMBERING SYSTEMS were considered in a series of conferences in the period 1873 to 1900, but little real progress was made toward securing the adoption of a single yarn numbering system by the different branches of the textile industry, particularly in the English-speaking countries. The need for standardization in this connection has increased because of the greater diversity of fibers in individual mills and increased international trade. As a result, interest in this subject has revived in recent years and proposals for universal numbering systems have been discussed both by the American Society for Testing Materials in the United States and by The Textile Institute in the United Kingdom. The subject was also discussed at length by the Textile Committee of the International Standards Organization in their meeting held in Buxton, England, in 1948. In this conference representatives of 15 countries agreed that a universal yarn numbering system should be direct,* decimalized, and based on metric units. Both the Grex [2] and gK [5] systems, which represent variations of these basic principles, received strong support. The following discussion presents a review of the respective merits of the Grex and gK systems, but it is not proposed to discuss in this paper the advantages of direct systems or the use of metric units, which have already been agreed upon. The paper is presented in the hope that a better understanding of the proposals will help everyone reach agreement on details and permit a concerted attack on the main job of obtaining the general adoption of universal yarn numbering by all branches of the textile industry.

Comparison of Grex and gK Systems

The Grex and gK systems are quite similar and may be described as follows:

"Grex" System

Yarn number is equal to the weight in grams of 10 kilometers (10,000 meters) of yarn; designation gx. (The Grex unit is one millionth of the c.g.s. unit of linear density, grams per centimeter.)

Yarn numbers range from 1 to 11 for most fibers and filaments and from approximately 15 for fine silk, rayon, and nylon yarns up to 5,560 for a 5,000-denier tire cord (equivalent to 1.06 hanks in the cotton system). Grex numbers up to 9,999 are recommended for yarns, plied yarns, and cords (equivalent to 9,000 denier or 0.60 hank in the cotton numbering system).

"gK" System

A. For Yarns. The yarn number is equal to the weight in grams per 1 kilometer of yarn (1,000 meters); designation gK. Yarn numbers range from approximately 1.5 for fine silk, rayon, and nylon yarns up to 556 gK units for a tire cord of 5,000 denier.

B. For Fibers and Filaments. The "yarn number" is equal to the weight in milligrams of 1 kilometer (1,000 meters) of yarn—mg K. Most fibers and filaments fall in the range of 1 to 10 denier and have numbers in the range of 110 to 1,110 mg K units.

Both the Grex and the gK systems would use supplementary units, 1,000 times larger than the units specified above, for the number of slivers, rovings, and heavier structures. For the Grex system, the larger unit would be designated as a kilogrex (kgx) unit, equivalent to kilograms per 10,000 meters; for the gK system, the unit is the kg K unit, equivalent to kilograms per kilometer. (These units are equal to grams per 10 meters and grams per meter, respectively.)

It will be noted that in the Grex and gK systems, as in the denier system, the yarn number increases with an increase in the dimension of the yarn.

Inspection shows that the Grex system employs a single unit (gx) to cover the numbers of staple

* Direct numbering systems are based on the weight of a standard length of yarn; in practice, the number of units of weight of a selected length of yarn give the yarn number directly. Yarn numbers in a direct system increase with yarn size or dimension. The denier and spyndle systems are examples.

TABLE I. COMPARATIVE YARN NUMBERS

Material	Denier system	Cotton system	Grex system	gK system
Staple fiber	1.00	5310.	1.11 gx	111. mg/K
Staple fiber	1.50	3550.	1.65 gx	165. mg/K
Staple fiber	3.00	1770.	3.33 gx	333. mg/K
Staple fiber	5.00	1060.	5.56 gx	556. mg/K
Staple fiber	10.00	531.	11.1 gx	1110. mg/K
Yarn	15.0	355.	16.5 gx	1.65 gK
Yarn	75.0	70.9	83.3 gx	8.33 gK
Yarn	90.0	59.1	100. gx	10.0 gK
Yarn	231.	23.0	257. gx	25.7 gK
Yarn	1100.	4.83	1220. gx	122. gK
Yarn	1650.	3.21	1830. gx	183. gK
Tire cord	2450.	2.17	2720. gx	272. gK
Tire cord	5000.	1.06	5560. gx	556. gK
Roving	3540.	1.50	3.94 kgx	.394 kg/K
Card sliver	60 grains/yard		42.5 kgx	4.25 kg/K
Lap	14 ounces/yard		4340. kgx	434. kg/K

fibers, yarns, and cords. In contrast, the gK system uses one unit for yarns and cords (gK) and a separate unit for fibers (mg K). The resulting numbers for fibers fall in the same range as the numbers used for yarns and cords, and it is obvious that if the proper designation is not given consistently in the gK system a certain amount of confusion is bound to result.

The use in the gK system of numbers for common staple fibers which actually are larger than the numbers for yarns made from the fibers is a violation of the spirit of a direct numbering system. Although the numbers in the gK system are mathematically correct because of the change in the base length, the practice is undesirable.

Furthermore, it will be noted that in each instance the number of digits in the Grex system is the same as in the denier system. The use of denier for silk, rayon, and synthetic fibers is universally understood and the industry in general has become accustomed to the mental picture of a fiber or yarn size expressed in terms of denier. Therefore, the Grex system, which differs only slightly from the denier system, has this further advantage over the gK system if a change is made.

Both systems would employ a larger unit for heavy structures, and it is desirable that the use of the larger unit be indicated automatically in case the actual designation is not included. For this purpose it is suggested that the use of the larger units be confined to *untwisted* structures such as rovings, slivers, and laps, in which case the accidental omission of the unit would not be apt to cause confusion. This separation between twisted and untwisted structures represents a natural division and the table indicates that the Grex system fits this natural division quite well whereas the use of the gK system will require additional decimal fractions for equal precision.

The similarities and differences between the systems can be illustrated by examples of typical commercial products, such as those given in Table I, in which the numbers have been rounded off to three significant figures.

While the values in Table I have, in all cases, been reported to three significant digits, the reader should not conclude that industry will necessarily continue to use staple fibers or yarns having the fractional numbers listed. Thus, it may well develop that spinners, weavers, and designers will use 1.5 grex per filament (150 mg/K) staple, instead of the common 1.65 gx filament product, and 100 gx (10 gK) yarn in place of the 100-denier (111 gx) yarn commonly sold at present.

Basis of Yarn Number Units

A moment's consideration indicates that yarn numbers may be made to assume any desired magnitude by choosing suitable units of length and weight. In the Grex system, units have been chosen which give values just above unity for most staple fibers and individual man-made filaments produced by commercial processes. This is a "natural" base in the case of natural fibers and is also appropriate for man-made fibers, since it is probable that the expense of spinning textile fibers finer than 1 denier per filament, together with their restricted merits, will always limit the amount of this type of production.

In the gK system the length and weight units have been chosen to give "two-digit numbers for common yarns" on the assumption that this is desirable and that three-digit numbers are cumbersome. As noted above, this is not actually realized since heavier yarns (less than 5.9 hanks in the cotton system, or over 900 in the denier system) will require three significant figures, and when the mg K units is used to avoid decimal fractions for staple fibers and single filaments, these will also require three significant figures. As mentioned previously, numbers used for fibers and cords are of the same order of magnitude and will not be automatically differentiated.

TABLE II. COMPARATIVE TENACITY AND BREAKING LENGTH OF RAYON STAPLE AND TYPICAL YARNS

Material	Breaking strength	Yarn No.	Tenacity As reported	Tenacity Grex system	Tenacity gK system	Breaking length
Rayon staple	3.3 g.	1.5 den.	2.2 g/den.	2.0 g/gx	0.02 g/mg/K	20 km.
Rayon yarn	220 g.	100 den.	2.2 g/den.	2.0 g/gx	20 g/gK	20 km.
Cotton yarn	104 lb.	20 hanks	2080*	1.0 g/gx	10 g/gK	10 km.

* Strength number (count) product.

It is questionable, also, whether or not the "two digits for common yarns" theory is actually a sound basis for selection. It certainly is not necessary, as is shown by the success of the man-made fiber industry, which uses the denier system employing three digits for common yarns and four digits for the heavy yarns used for tire cords. It is also a well-established practice to use four-digit numbers in the denier system for all cords made from rayon yarns. The use of still larger numbers has been advocated [3]. In this connection it can be stated that in the extensive balloting which preceded the adoption of the Grex system by the American Society for Testing Materials, Committee on Textile Definitions, none of the voters raised any objection to the use of three digits for common yarns.

Numbers of yarns finer that 59 in the cotton system (90 denier) will require a decimal fraction when measured in the gK system. This will apply to fine cottons, almost all silk and nylon yarns, and to large amounts of other man-made yarns. To burden these industries with the gK system requiring the use of decimal fractions, frequently unnecessary in the Grex system, is a serious handicap and should be avoided. The desirability of eliminating decimal fractions from common yarn numbers is conceded by the sponsors of the gK system, who have resorted to the expedient of a secondary unit to avoid having numbers for staple fibers which are largely decimal fractions. It would appear that if the principle is right for staple fibers, then it should be applied as far as possible to all yarn numbers.

The "two digits for common yarns" proposal is actually *undesirable* from the point of view of a yarn producer. The manufacturer determines and makes use of yarn numbers many times a day in a modern mill, and he is the one whose needs should be given more consideration than those of the designer, purchasing agent, statistician, stock clerk, or tax collector, who uses a number once to represent thousands of hours of production and many actual determinations of yarn number. Any producer who is trying to make a uniform product—say, within 1% to 3% of the specified number—must use three significant figures to measure his production. Table I shows, for example, that 100-denier yarn is approximately equal to 110 grex or 11 gK, but any producer filling an order for 11 gK yarn with a product that varies from 10 gK to 12 gK would have it returned as unacceptable. What is wanted is something averaging between 10.7 and 11.3 gK ($\pm$ 3%), and if production must be controlled in this manner, there is no reason why the spinner (the one who uses yarn numbers most) should be unnecessarily burdened with decimal fractions in the three digits which are required for the control of quality in good textile yarns.

The textile trade—excepting producers and technicians—will of course continue to use round numbers, as it does now when dealing with yarn sold in denier units.

One of the merits of any system based on decimalized units is its flexibility. The use of kilogrex units for heavy structures has already been mentioned, and other units based on the metric system can be used so that the units required to give two-digit numbers are actually available for the whole range of yarn sizes for either the Grex or gK system, if this proves desirable.

For example, 150 grex can be written as 15 dekagrex; 12 hectogrex can be written as 1,200 grex, and, in general,

$$\begin{aligned}\text{Grex numbers} &= 10 \times \text{dekagrex numbers} \\ &= 100 \times \text{hectogrex numbers} \\ &= 1{,}000 \times \text{kilogrex numbers};\end{aligned}$$

also

$$\text{gK numbers} = \text{dekagrex numbers}.$$

In the long run, experience will determine whether two-digit numbers are most desirable for a selected set of "common yarns," or for all yarns. At present we believe that the frequent shifting of units is un-

TABLE III. COMPARATIVE TWIST FACTORS

Cotton system Turns per in.	Grex system Turns per in.	Grex system Turns per cm.	gK system Turns per in.	gK system Turns per cm.
2.5	190	75	60	24
5.0	385	150	120	48
10.0	770	300	240	96
Conversion factor	76.9	30.2	24.3	9.57

TABLE IV. COMPARATIVE COVER FACTORS

Cotton system Yarns per in.	Grex system Yarns per in.	Grex system Yarns per cm.	gK system Yarns per in.	gK system Yarns per cm.
7	540	210	170	67
14	1075	425	340	135
28	2150	845	680	270
Conversion factor	76.9	30.2	24.3	9.57

desirable because of the possible confusion of numbers and because of the extra work required to indicate which unit has been employed.

Calculation of Yarn Tenacity

The basic length and weight used to define a unit yarn number determine the magnitude of the numbers of common yarns, and also of related tenacity * and breaking length † values, as shown in Table II.

It will be seen that the smaller yarn numbers of the gK system are reflected in proportionately higher values for g/gK tenacities, and these are equal to the breaking length expressed in kilometers.

The breaking-length value, in kilometers, is 10 times the tenacity reported as g gx, or 1,000 times the tenacity reported as g/mg/K units. The equality of g gK tenacity and breaking-length values offers a slight advantage in those countries where breaking length is commonly used. At present, however, breaking length is seldom used in the English-speaking countries, and of the many yarn number determinations made, relatively few are used to calculate tenacity values. It is believed, therefore, that the somewhat simpler relationship between breaking length and gK numbers, which would be a slight advantage for the continental countries, would not compensate all countries for the other relatively cumbersome characteristics of the gK system when used for yarn numbering generally.

Calculation of Twist Factor and Cover Factor

Another calculation depending upon yarn number is that of twist factor (twist multiplier), an empirical number which increases directly with the twist in the yarn and the size of the yarn. The absolute value depends upon the system used to determine the yarn number and the basis of reporting the twist; *i.e.*, turns per inch, turns per centimeter, etc.

$$\text{Twist factor} = \frac{\text{Twist}}{\sqrt{\text{Yarn number in indirect (reciprocal) systems}}}$$

or

$$= \text{Twist} \times \sqrt{\text{Yarn number in direct systems.}}$$

Table III gives twist factors based on Grex and gK direct systems equivalent to the common factors of 2.5, 5.0, and 10.0 based on yarns numbered in the cotton system and having twist expressed in turns per inch.

Cover factor, an indication of the closeness of the weave, is another empirical number which increases directly with the count of the fabric and the size of the yarns. As with twist factors, the absolute value depends upon the system used to determine yarn number. Thus,

$$\text{Cover factor} = \frac{\text{Number of yarns (per in., cm., etc.)}}{\sqrt{\text{Yarn number in indirect (reciprocal) systems}}}$$

or

$$= \text{Number of yarns} \times \sqrt{\text{Yarn number in a direct system.}}$$

Values in the Grex and gK systems comparable to cover factors of 7, 14, and 28 calculated from yarns per inch and yarn number measured in the cotton system are given in Table IV.

It will be noticed that the same conversion factors are used for the calculation of both twist factors and cover factors from numbers based on the cotton system and turns per inch or threads per inch. The corresponding factors for numbers based on the worsted system and turns per inch or threads per inch are 94.7, 37.3, 29.8, and 11.7, respectively. Other conversion factors can be readily calculated.

* Tenacity is defined as breaking strength calculated to a unit yarn number basis as grams/denier or the product of breaking strength per lea and yarn number in an indirect (reciprocal) system.

† Breaking length is defined as the calculated length of a yarn which will break of its own weight, assuming that it has been suspended by one end.

Present Status of Grex and gK Systems

The adoption of a universal yarn numbering system in democratic countries must necessarily be a slow process because of the tremendous inertia present and the lack of enthusiasm in those persons who have worked principally with one fiber and have, up to the present, gotten along with one system used for a particular fiber. A system for basing silk yarn numbers on grams per 10,000 meters was first proposed at a "Yarn Number Conference" in Brussels in 1874, and since it was revived in 1942 in the U. S. under the name of the Grex system it has made definite progress. It was adopted as a Tentative Recommended Practice by the American Society for Testing Materials, Committee D-13 on Textiles, in 1945 and was advanced to standard status in 1947. It has been adopted by the United States Government Federal Specifications Board as an alternate method for specifying yarn numbers. It has been used to some extent in the technical press [4], especially in articles that discuss a number of fiber types, and it is used to some extent in private laboratories.

Prior to its revival in the United States, and quite independently, the Grex system, under another name, had been used by the Alpargatas cotton spinning mills in Argentina and Uruguay. The operators of these mills report complete satisfaction with the system after many years' experience [1].

In the light of this progress, it seems very undesirable, therefore, to change to another system unless the other has demonstrably important advantages. A careful study of the gK system reveals that it does not have such advantages and is, in fact, definitely less desirable in several respects, so that its adoption would be a backward step and might delay the adoption of any universal system in the United States for many years.

The word *Grex* was coined to indicate the basis of the system (*Gr* from *grams*, *e* from *per*, *x* from *10 in 10,000 meters*). As such, it is a convenient but not an essential part of the system, which should be judged on its merits irrespective of the name applied up to the present.

The gK system has not been used commercially, but its use has been decreed in Spain. However, it is not thought that the decision by arbitrary authority to use it in a country with a relatively small textile industry can be compared with the considered opinion of the technical representatives of the large textile industry in the United States, as expressed in the American Society for Testing Materials Recommended Practice D861–45T [2] and in D861–47 [2a].

Conclusion

Consideration of the previous discussion shows that the Grex system has definite advantages over the gK system and should be given careful consideration when a universal yarn numbering system is selected.

Advantages of the Grex system discussed in this paper include:

1. Ability to handle fibers, filaments, yarns, and cords all in one integrated system having an ascending scale extending from 1 to 9,999 Grex units.
2. A supplementary scale for yarn intermediates that requires fewer decimals than the corresponding values of the gK system for typical rovings and slivers.
3. Generally less dependence upon decimal fractions for the precision required by those who use yarn numbers most.
4. Easier calculation of fiber tenacities.
5. No confusion between fiber numbers and cord or twine numbers.

Literature Cited

1. Letter to the Editor. *Textile Age* **8**, 108 (Apr. 1944).
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4. Smith, H. DeWitt, *Am. Soc. Testing Materials, Proc.* **44**, 543–92 (1944).
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ABSTRACTS

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A list of periodicals, the abbreviations used in reference to articles, and the addresses of publishers of English-language publications is given in the January, 1949, issue, page 46.

ANALYSIS: TESTING: LABORATORY METHODS

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Analysis of Dyes

Colorimetric analysis of dye mixtures. D. L. MacAdam. *J. Optical Soc. Am.* **39**, 22–30 (Jan. 1949).

While this investigation was undertaken because of its bearing on color photography and on the choice of colorants for subtractive processes, the results should nevertheless be of interest to textile dye chemists. Distributions of chromaticities were computed from spectral characteristics of 171 pairs of typical dyes (5 yellows, 9 cyans, 9 magentas). Beer's law was assumed, and the concentration in each mixture was varied systematically, 90 chromaticities being computed for each pair of dyes. Since each dye was used in combinations, with combinations of as many as 18 other dyes, the results show the influence of spectrophotometric characteristics on chromaticity distribution, gamut, and luminous transmittance. Very extensive computations were necessary for this highly practical and basic study, for there is no shortcut method for studying colorant mixtures. Calculations made to obtain colorimetric data must be computed for every pair from spectral distribution data. The enormous number of calculations for this study were made possible by the author's systematic use of IBM equipment. Illuminant C was used as the standard source, and the 30-selected-ordinate method was used for colorimetric calculation. The results are shown on a series of 20 diagrams, many of them mixture diagrams, some showing the complete series of mixtures of 3 pairs of dyes for all the concentrations studied, others showing the dependence of the gamut for pairs of similar colors upon the spectral characteristics of component dyes. *Text. Research J. May 1949* D. Nickerson

An outline of qualitative dye analyses. W. E. Mathewson. *Am. Dyestuff Reptr.* **37**, 709–25 (Nov. 1, 1948).

The separation of mixtures of dyes by the use of immiscible solvents is described. A table is presented in which dyestuffs are listed in 10 groups in accordance with their approximate relative distribution in certain immiscible solvents, as observed with commercial dyes in concentrations of about 0.05–0.005%. Tests for the identification of separated dyes are described. A procedure for extracting vat dyes from textiles by the use of *n*-butylamine is included. Tables list the color changes of solutions of dyes with hydrochloric acid, sodium hydroxide, and sodium hydrosulfite, the colors of solutions of dyes in concentrated sulfuric acid, and the color changes of the sulfuric acid solutions on addition of divanadyl trisulfate. The bromine oxidation test is described. This test is very useful in separating dyes into various classifications. C.A.A.
Text. Research J. May 1949

Fastness of Dyes to "Trubenizing"

The fastness of dyes to "Trubenizing." C. Zuber and P. Dechatre. *Teintex* **13**, 273–7 (1948) (through *Chem. Abstr.* **42**, 8478e (Nov. 10, 1948)).

Laboratory tests on 62 vat dyes showed they could be classified into 3 categories: (1) satisfactory, (2) to be used with precautions, and (3) unsatisfactory for use in fabrics to be trubenized. The test consists of placing a deeply dyed piece of fabric between two white pieces of cloth and immersing for 10 sec. in a solution of Me_2CO and EtOH (3:1), and then pressing with a hot iron (120°C) until dry. The coloration

of the solution and the white pieces of cloth indicated the relative fastnesses of the dyes tested.

Text. Research J. May 1949

Deterioration of Organic Materials

Microbiological deterioration of organic materials: Its prevention and methods of test. E. Abrams. U. S. Dept. of Commerce, Natl. Bur. Standards, Miscel. Publ. No. 188 (Nov. 1, 1948).

Literature on the microbiological deterioration of paper, hemp, fabrics of cotton, wool, and flax, leather, nylon, rubber, and plastics has been reviewed, with 179 references. Investigations of microbiological testing procedures at the Bureau suggest that the soil-burial test, especially under controlled temperature and moisture conditions, is the most practical. It was pointed out, however, that no single test can be used to determine the usefulness of materials under all service conditions. When the end use involves a variety of conditions, the Chaetomium-mycelial mat technique, with and without the use of prior accelerated weathering, should be carried out together with the soil-burial method. The conclusions were supported by the evaluation of 35 fungicidally treated fabrics by the various test methods. The superiority of copper naphthenate over zinc derivatives and the chlorinated phenols has been confirmed. Of the mercury fungicides, the pyridyl mercuric compounds appeared most effective. Paranitrophenol and pentachlorophenol proved satisfactory fungicides for vegetable-tanned leather, in which the grease component appears to be mainly responsible for the extensive mildewing. Of the 15 polymers and 85 plasticizers tested against *Aspergillus niger* on a complete medium, only urea-formaldehyde showed resistance. On sugar-free medium, 4 of the polymers and 15 of the plasticizers supported mold growth.

R. G. H. Siu

Text. Research J. May 1949

Detection of Resins in Viscose

The detection of thermosetting resins in viscose fibers. R. Bernegger. *Textil-Rundschau* **3**, 191–201, 226–36, 272–80 (1948) (through *Chem. Abstr.* **42**, 8479*f* (Nov. 10, 1948)).

Resins could not be detected satisfactorily by the use of dyes with special affinity for resins because the resin on the fiber edge was not indicated. Coupling of the resin with intermediates to form a dye was not satisfactory. Nitrosation of secondary amino groups in the resin prior to coupling gave a weak yellow color, but only at high resin concentrations. A workable technique consisted in liberating HCHO from the resin by hydrolysis with 0.05*N* NaOH and treating with Tollens reagent to form a readily visible deposit of Ag. Good photomicrographs in which the position of the Ag deposit corresponds to the original position of the resin could be made by this technique. When resin impregnation was properly carried out with fresh solutions of resins of low molecular weights, the finished product contained resin throughout the fiber. Aged solutions contained resins of higher molecular weights in which the molecules were too large to penetrate the fiber and settled on the fiber surface. Reaction between cellulose and HCHO, in the sense discussed by Götze and Reiff (*C.A.* **37**, 2570[5]), occurred when NH_4Cl was used to catalyze the resin condensation, but not when HCOOH was used. HCHO resins can be extracted from the fiber with a solution of Na_2CO_3 and Na_2SO_3 and studied in this form for further identification. A review of previous work in this field is included. 36 references.

Text. Research J. May 1949

Sectioning Fibers

A new method of sectioning synthetic fibers with the ultra-microtome for examination with the electron microscope. Marshall D. Earle and Jean A. Minkin. TEXTILE RESEARCH JOURNAL **19**, 36–41 (Jan. 1949).

A method has been devised in which a piece of rayon or nylon yarn, consisting of 10 or 20 single filaments, is prepared for sectioning with the high-speed ultra-microtome in such a way that the boundaries of individual filaments can be identified when viewed in the electron microscope. The yarn is mounted in a special holder in which the filaments are spread out radially. They are then coated with a thin film of evaporated gold in the vacuum unit. These filaments are allowed to fall parallel to each other again. They are embeded in a very thin layer of low-melting-point paraffin and sectioned with the ultra-microtome. The thin film of gold enables one to determine whether the area being studied is near the surface of the filament.

Authors

Text. Research J. May 1949

Jute Filaments

The elastic properties of single jute filaments. I. Measurement and study of Young's modulus by flexure. K. R. Sen. *J. Text. Inst.* **39**, T339–50 (Oct. 1948).

An instrument is described for studying the flexural rigidity of single jute filaments by measuring the load required to bend a single layer 2 cm. wide consisting of 150 parallel filaments. Results on different varieties of jute are reported and discussed. Fibers from different parts of the reed in the raw as well as in the batched condition are investigated and the effect of humidity is observed. A study is made of jute filaments at different stages in the growth of the plant.

L. P. Witnauer

Text. Research J. May 1949

Determination of Chlorine in Polymers

Determination of the chlorine content in polymers. K. Stoeckhert. *Kunststoffe* **37**, 53–4 (1947) (through *Chem. Abstr.* **42**, 7570*g* (Oct. 10, 1948)).

A new method is described which takes only 3–4 min. and by which chlorine is determined gravimetrically or titrimetrically. About 0.2 g. of polyvinyl chloride is mixed intimately in an iron crucible with

20 times that amount of a finely powdered mixture of 1 part anhydrous Na_2CO_3 and 3 parts Na peroxide. The mixture is ignited by a red-hot iron wire through a hole in the lid of the crucible. After completion of the reaction (the mass must be well melted) it is heated further for 2 min. to dark-red hotness. After cooling (not quenching) the melt is dissolved with warm water from the crucible and the solution is boiled in a covered beaker until no more oxygen is evolved. 3 cc. of saturated $NaHSO_3$ solution is added and enough H_2SO_4 to dissolve all Fe hydroxide. It is then boiled until SO_2 odor disappears, and then a little HNO_3 is added. Cl is then determined with $AgNO_3$ gravimetrically or titrimetrically.

Text. Research J. May 1949

Free Radicals

The mechanism of the Gomberg reaction. A reply to H. H. Hodgson. D. H. Hey and W. A. Waters. *J. Soc. Dyers and Colourists* **64**, 359–61 (Nov. 1948).

The authors restate their case relative to the mechanism of the Gomberg reaction wherein they have postulated that some decomposition reactions of diazo compounds may be explained by free radials. Hodgson (*J. Soc. Dyers and Colourists* **64**, 99 (1948)) believes that the Gomberg reaction can be explained on a simple electronic basis.

Text. Research J. May 1949 C. Amick

Reactivity of Cellulose

Testing of fibers for the preparation of cellulose acetate. II. Determination of degree of reactivity. G. Jayme and U. Schenk. *Angew. Chem.* **A60**, 46–7 (1948); cf. *C.A.* **39**, 2402[8] (through *Chem. Abstr.* **42**, 7979*a* (Oct. 20, 1948)).

A method is presented which permits the determination of the effect of hemicellulose as well as the reactivity of the fibers towards acetylating reactions. The basis of the standardized method is a comparison of results obtained by an activating pretreament with glacial AcOH at 90°C on the one hand and by simple preswelling with glacial AcOH at room temperature on the other hand. The changes in initial and final turbidity values of the primary solutions and the respective sedimentation heights are the criteria for evaluation. Experimental results are presented.

Text. Research J. May 1949

Stress Relaxometer

An autographic stress relaxometer. R. S. Stein and H. Schaevitz. *Rev. Sci. Instruments* **19**, 835–9 (Dec. 1948).

An autographic stress relaxometer for measuring the relaxation of stress at constant length of an elongated polymer is described and schematically illustrated. Two linear, variable differential transformers are employed, one for measuring the force, the second for maintaining the sample at constant length. A typical curve obtained in a relaxation experiment is shown.

L. P. Witnauer

Text. Research J. May 1949

Testing Cotton-Fiber Strength

A modification of the flat-bundle test method for testing cotton-fiber strength. J. K. Phillips. TEXTILE RESEARCH JOURNAL **18**, 684–6 (Nov. 1948).

A new testing technique is described in this paper which permits the use of the Pressley fiber jaws on the Scott IP-4 tester to measure the tensile strength of cotton fiber. This method also makes it possible to test the flat bundle at different test-specimen lengths or jaw spacings. Some data are included which show the effect of increase of test-specimen lengths on the tensile strength of cotton fiber and other textile fibers. Author

Text. Research J. May 1949

Testing Enzymes

The testing of enzymic washing media. II. A method for determining enzymic proteolytic power. A. K. Vlček, D. Krkošková, and V. Mansfeld. *Chem. Obzor* **18**, 41–2 (1943); cf. *C. A.* **38**, 5616[6] (through *Chem. Abstr.* **42**, 8482*a* (Nov. 10, 1948)).

Dry and washed woolen, cotton, silk, or synthetic fiber sheets were soaked in a 0.6% protein solution (containing a pigment) for 60 min., wrung by hand, and dried in the air 24 hrs. For proteins, gelatin, serum albumin, globulin, casein, milk, or blood served well. At least two 10 × 10-cm. squares cut from the treated cloth were immersed in 200 cc. of a 0.2% enzyme solution kept at 40°C for 40 min. and for 12 hrs. with constant shaking. After a cold-water rinse the squares were wrung and dried. Besides the subjective comparisons of the treated squares to controls, the colorimeter readings gave a measure of the turbidity of the pigment and protein in the solutions and the Lange electric photometer compared the whiteness of the squares. Enzymes of a pancreatic origin acted equally upon all of the natural proteins except upon natural and upon heat-denatured albumin. Enzymes of a non-pancreatic origin acted quickly (in 40 min.) upon natural and denatured albumins, globulin, and blood. Upon films of milk they did not have any effect in 40 min. and attained a corresponding effect after 8 hrs. These preparations contain chymosin, in addition to proteinases, which converts the caseinogen of milk into casein. The casein shrinks and concentrates the pigment, giving the square a darker appearance than it had at the beginning. After the proteolytic enzymes exerted their action, they dissolved the casein and released the pigment.

Text. Research J. May 1949

Textile Test Machine

A new machine for dynamically testing textiles and rubber. A. Tenot. *Génie civil* **124**, 349–51 (1947) (through *Chem. Abstr.* **42**, 9185*a* (Nov. 20, 1948)).

Working plans are shown, and explained, of a machine which measures and records elongation produced by a static load, range of elongation produced by alternating

loads, permanent deformation, and number of cycles.

Text. Research J. May 1949

Yarn Diameter Measurement

Composite frequencies in yarn-thickness variations (shown by an air-flow method). W. L. Balls. *J. Text. Inst.* **39**, T225–31 (July 1948).

A pneumatic tester designed for measuring variations in yarn diameters is described. An incoming stream of air is split into 2 identical coarse capillary paths and escapes through 2 identical nozzles so shaped that a strand of yarn can be drawn through one of them while the other remains unobstructed. The pressure difference between that on the open side and that on the side partly choked by the yarn is shown by a differential water-manometer, a large pressure difference indicating a thick place in the yarn, and a small difference a thin place. To minimize trouble from its surface hairiness, the yarn is given a preliminary gassing. For this, simple laboratory-bench equipment was designed. Test results on Egyptian yarns suggest that yarn-thickness variability is dependent upon hair properties in the thinner portions, but upon drafting methods in the thicker portions. The method of test is an unfinished technique showing promise of usefulness.

J. Tallant

Text. Research J. May 1949

CHEMICAL and PHYSICAL RESEARCH

★

Moisture Adsorption of Acetate

Moisture adsorption by cellulose acetate. M. Taniguchi and M. Hosono. *J. Soc. Chem. Ind. Japan* **46**, 1103–5 (1943) (through *Chem. Abstr.* **42**, 6531*a* (Sept. 10, 1948)).

Air-dry pulverized cellulose acetate does not reach equilibrium even in 24 hrs. at 25°C in an atmosphere of 95% relative humidity; a film prepared from Me_2CO solution reaches equilibrium in 3 hrs. The degree of solvation of the film affects its adsorption of moisture—that is, a film containing 8.1, 3.2, and 0.1% of Me_2CO adsorbed 2, 8.2, and 12.2%, respectively, of moisture when equilibrium was reached.

Text. Research J. May 1949

Structure of Amyloses

An investigation of the streaming birefringence of amylose solutions. J. F. Foster and I. H. Lepow. *J. Am. Chem. Soc.* **70**, 4169–73 (Dec. 1948).

The amylose component of starch is readily orientable in a streaming gradient. A study has been made of the effect of temperature, solute concentration, and solvent composition using as solvent mixtures of glycerol and ethylene diamine. Comparison of amyloses from corn, tapioca, potato, and lily-bulb starches give results in qualitative agreement with their relative intrinsic viscosities. The results are discussed on the basis of the orientation theory, with the conclusion that the effect in the case of the amylose is predominantly due to elongation of coiled molecules rather than to simple orientation. Authors

Text. Research J. May 1949

Carboxyl Groups in Cellulose

Determination of carboxyl groups in cellulose. K. Wilson. *Svensk Papperstidn.* **51**, 45–9 (1948) (through *Chem. Abstr.* **42**, 6535*f* (Sept. 10, 1948)).

After reviewing the different methods proposed for the determination of carboxyl groups in cellulose, Wilson gives in a graph values for the relationship between pH and cation (Na) uptake for 4 different cellulose samples. The samples are first made cation-free by washing with 0.1*N* HCl, suspended in 0.01*N* $NaHCO_3$ and 0.01*N* NaCl or 0.01*N* NaOH and 0.01*N* NaCl for 1 hr., the fibers are removed, and an aliquot of the filtrate is titrated with 0.01*N* HCl by using methyl red as indicator and establishing the end point after boiling off the CO_2. The graph shows a fairly consistent break in the curves at pH of about 8.6, above which Wilson assumes that acidic groups weaker than the carboxyl group react. Since 0.01*N* $NaHCO_3$ gives a pH lower than, but close to, 8.6, Wilson's method consists of adding 2.5 g. defibered and 0.1*N* HCl-washed cellulose to 50 ml. 0.01*N* $NaHCO_3$, plus 0.1*N* NaCl for neutralization of the carboxyl group. After 1-hr. reaction time (or overnight if the sample was dried at 60°C after the HCl wash) the fibers are filtered and 25 ml. of the filtrate are titrated with 0.01*N* HCl. The carboxyl content (expressed as millequivalents 100 g. dry sample) is given for 7 different cellulose products analyzed by the above method as well as by using AcONa, $(AcO)_2Ca$, NaOH, Ag *o*-nitrophenolate as the cation donors. The first two reagents gave lower and the latter two higher values than the $NaHCO_3$ method.

Text. Research J. May 1949

Titration of Cellulose

The use of sodium chloride in the determination of acid values of cellulosic materials. P. B. Sarkar, A. K. Mazumdar, and K. B. Pal. *Current Sci.* (India) **17**, 88–9 (1948) (through *Chem. Abstr.* **42**, 6535*e* (Sept. 10, 1948)).

Titration of jute fiber suspended in NaCl with 0.02*N* NaOH (bromothymol blue as the indicator) gives the most consistent results.

Text. Research J. May 1949

Detergency Studies

Studies in soiling and detergency. J. R. Clark and V. B. Holland. *Am. Dyestuff Reptr.* **36**, P734–47 (Dec. 15, 1947).

A standard soil was developed consisting of the following: 0.25% Alkanol WXN (an alkyl aryl sulfonate), 2.0% oildag (colloidal graphite in oil), 8.0% Gulf 3F Fibre Spray Oil, and 89.75% Stoddard Solvent. An extensive study was made, with results indicating that the type of soil, sample area, length of wash, washing temperature, and type of fabric all have a

pronounced effect on removal of soil by any detergent.

K. S. Campbell

Text. Research J. May 1949

Dichroism of Fibers

Dichroism of fibers. II. S. Okajima and S. Kobayashi. *J. Soc. Chem. Ind. Japan* **49**, 38 (1946) (through *Chem. Abstr.* **42**, 6540*h* (Sept. 10, 1948)).

Ramie and cotton fibers were dyed with Congo red and their dichroism was measured. The theory that molecules of dye are directly adsorbed by cellulose in definite positions in the micelle surface parallel to the axis of the micelle is confirmed, and the micelle orientation can be ascertained by determining dichroism. This can be used as a means of studying microstructure side by side with x-ray and other optical methods.

Text. Research J. May 1949

Dichroism. VI. Swelling and dichroism of rayon in sodium hydroxide solution. S. Okajima, Y. Nakayama, and F. Adachi. *J. Soc. Chem. Ind. Japan* **49**, 128 (1946) (through *Chem. Abstr.* **42**, 6541*a* (Sept. 10, 1948)).

There was no difference between the dichroism constants ($K_{\parallel}/K_{\perp}$) of dry rayon and of rayon swelled in water. A study of dichroism of rayon in NaOH solution and of the relation between dichroism constant and degree of swelling failed to give notable results.

Text. Research J. May 1949

Mercerization

Mercerization of cellulose. I. Calorimetric study. E. Calvet. *Compt. rend.* **226**, 1275–6 (1948) (through *Chem. Abstr.* **42**, 6123*a* (Aug. 20, 1948)).

The heat of immersion of 10–20 mg. of natural cotton linters, containing 3.5% moisture (heat of hydration, 6 cal.), in NaOH solutions at 17°C was determined. The curve $Q = f(N)$ (where Q = cal. liberated/g. cellulose and N = g. mol. NaOH/l.) does not go through the origin and $Q = 3$ from $N = 0$ to 0.5. Q then increases linearly to $N = 6$ (19.6% NaOH). At this point dQ/dN falls rapidly (this shows that mercerization is endothermic), and then increases to its original value at $N = 10$. The heat of mercerization, −3.6 cal. g., in 5.26N NaOH is the difference between Q for ordinary cellulose, 23.4 cal., and Q for mercerized cellulose, 27.2 cal. The absorption of 6N NaOH by cellulose is not reversible at ordinary temperature. Thus, Q is greater for cellulose immersed in 6N NaOH which is then diluted to 3N than it is for cellulose immersed directly in 3N NaOH, because mercerized cellulose absorbs more NaOH than unmercerized cellulose. By this method, the heat of mercerization is also about −4 cal. g. cellulose.

Text. Research J. May 1949

Polyacrylic Fibers

The spinning of synthetic high-molecular compounds. I. Dry spinning of polymethyl methacrylate. I. Sakurada, R. Inoue, and T. Morita. *J. Soc. Chem. Ind. Japan* **46**, 1199–1201 (1943) (through *Chem. Abstr.* **42**, 6540*g* (Sept. 10, 1948)).

The tensile strength increased with increasing degree of polymerization. **II. Dry spinning of polyethyl methacrylate.** *Ibid.* 1201–3. The tensile strength increased with the degree of polymerization. **III. Wet spinning of polymethyl methacrylate.** *Ibid.* 1204–5. The spinnability increased linearly with the bath temperature, when Me_2CO was used for the original solution and water for the spinning bath.

Text. Research J. May 1949

Chlorinated Polyvinyl Chloride Fiber

Polyvinyl chloride and its derivatives. IV. Production of chlorinated polyvinyl chloride fiber. H. Ohe. *J. Soc. Chem. Ind. Japan* **45**, 977–80 (1942) (through *Chem. Abstr.* **42**, 6158*c* (Aug. 20, 1948)).

Chlorinated polyvinyl chloride having 63.3–72% chlorine was dissolved in 1:1 mixtures of $Me_2CO + C_6H_6$ or $Me_2CO + CCl_4$, spun into MeOH, and mechanically stretched. Before stretching, the fiber had a tensile strength of 0.58 g. per den. and an elongation of 95.7%; these were changed to 2.70 g./den. and 15.9%, respectively, by stretching. Increase in strength was proportional to the decrease in elongation at the first stage of stretching, while a great increase in the former without much loss in the latter was observed at later stages. A stronger fiber was obtainable with a solution of the same concentration having higher specific viscosity. Cyclohexanone as a solvent was difficult to remove completely after spinning.

Text. Research J. May 1949

Softening Points of Vinyl Fibers

Polyvinyl chloride and its derivatives. VII. Relation between the amount of chlorine content and the softening point of chlorinated polyvinyl chloride fiber. H. Ohe. *J. Soc. Chem. Ind. Japan* **46**, 1109–(?) (1943) (through *Chem. Abstr.* **42**, 6158*h* (Aug. 20, 1948)).

Softening points of various samples of chlorinated polyvinyl chloride fiber were measured by means of a special apparatus in which the sample was hung with a weight and heated very slowly from the outside. The elongation at different temperatures was observed and, from the plot of elongation or log of elongation against temperature, the softening point was suitably determined. The content of solvent remaining in the fiber had a great effect on the softening point, and the sample must be as free from solvent as possible. The softening point is raised with increase in chlorine content of the product; some samples showed a softening point higher than 120°C.

Text. Research J. May 1949

Wettability of Polymers

Wettability of high-molecular substances by water. I. Sakurada and M. Taniguchi. *J. Soc. Chem. Ind. Japan* **49**, 35 (1946) (through *Chem. Abstr.* **42**, 6206*b* (Sept. 10, 1948)).

Wettability is defined as the cosine of the angle θ that a solid surface

makes with a liquid in contact with it and can be determined by measuring the height h of capillary of radius r from $\gamma \cos \theta = (r/2) - \rho g h$, where γ and ρ are the surface tension and specific gravity of the liquid, respectively. Thus, wettability ranges from 1 to −1. The degree of absorption of moisture and wettability are not the same thing—that is, polyvinyl alcohol has a very large value for the former in comparison with its wettability by water, whereas polyvinyl acetate has the opposite properties. Neither polystyrene nor paraffin absorbs moisture, but their wettabilities by water are different. Wettability of cellulose acetate is independent of the degree of polymerization, but the absorption of moisture depends on the latter.

Text. Research J. May 1949

Polysaccharide Thiocyanates

The thiocyanation of polysaccharide tosyl esters. J. F. Carson and W. Dayton Maclay. *J. Am. Chem. Soc.* **70**, 2220–3 (June 1948).

The tosyloxy group in the primary position of carbohydrate molecules can be replaced by thiocyanate, using freshly distilled acetonylacetone and sodium thiocyanate (dried *in vacuo* at 100°C) under anhydrous conditions at 110–12°C. This reaction, like the similar iodination, serves as a quantitative means of determining the primary OH groups in cellulose, cellulose derivatives, potato starch, and guar mannogalactan. The reaction with hemicellulose apparently is not confined to the primary OH.

A. R. Macormac

Text. Research J. May 1949

Spinning Viscose

Single-bath spinning of viscose with stretch. M. Horio, M. Takahama, and H. Hashimoto. *J. Soc. Chem. Ind. Japan* **47**, 385–8 (1944) (through *Chem. Abstr.* **42**, 6533*e* (Sept. 10, 1948)).

By using stretch in the single Müller H bath at 70–8°C, the strength of the yarn was markedly increased, and an effect comparable with that of the 2-bath method was realized. The effect of stretching appears in all parts of a cross section of the fiber and is fixed fairly well.

Text. Research J. May 1949

The two-bath spinning of viscose rayon. M. Horio and S. Nagata. *J. Soc. Chem. Ind. Japan* **46**, 706–11 (1943) (through *Chem. Abstr.* **42**, 6533*f* (Sept. 10, 1948)).

Viscose rayon was stretched after leaving the first coagulation bath and then wound on a cylinder revolving in the second bath at 10°C. When the composition of the first bath is so regulated by proper addition of $ZnSO_4$ that the fiber at the point of stretch contains about 20% of undecomposed viscose, the product has a wet tensile strength 20–80% higher than that produced by the single-bath method. The second bath is dilute H_2SO_4 containing Na_2SO_4. The product of the new process has more than 70% skin layer of orderly arranged molecules, whereas the fiber of the single-bath process has only 40%.

Text. Research J. May 1949

Wool Hydryzate

Separation of acidic amino acids by means of a synthetic anion-exchange resin. R. Consden, A. H. Gordon, and A. J. P. Martin. *Biochem. J.* **42**, 443–7 (1948) (through *Chem. Abstr.* **42**, 6542*e* (Sept. 10, 1948)).

The glutamic and aspartic acids in a wool hydrolyzate were separated by the chromatographic method by using the synthetic anion-exchange resin, Amberlite IR4. Cystic acid was also isolated by this procedure from chlorine-treated wool, and the method is discussed.

Text. Research J. May 1949

BLEACHING: DYEING: FINISHING

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Garment Bleaching

The bleaching of clothes. W. Kind. *Melliand Textilber.* **28**, 165–9 (1947) (through *Chem. Abstr.* **42**, 8482*a* (Nov. 10, 1948)).

The deleterious effects of various household bleaching practices are measured.

Text. Research J. May 1949

Fluorescent Bleaching Agents

Bleaching with fluorescent bleaching agents. A. Landolt. *Textil-Rundschau* **3**, 376–82 (Nov. 1948).

Various substances which have been used as fluorescent bleaching agents are enumerated. Two new fluorescent bleaching agents—one for cotton (Uvitex RS) and the other for wool, silk, and acetate rayon (Uvitex WS) have been developed by the Swiss firm CIBA. Fluorescent bleaching agents emit fluorescent light in the visible spectrum, giving whiteness of great brilliance to the fibers without extended bleaching or weakening of the fibers. Diagrams show the dependence of brightness upon bleaching-agent concentration for various fibers.

Text. Research J. May 1949 J. F. Krasny

New Dye Products

Alphabetical list of new products developed since November, 1947. *Am. Dyestuff Reptr.* **37**, 805–26 (Dec. 13, 1948).

Data are presented on the dyestuffs and pigments, textile chemicals, and equipment which have been placed on the market or further developed since November, 1947. C.A.A.

Text. Research J. May 1949

Textile Printing

Notes on the effect of cloth structure in textile printing. J. H. Downey. *Textile Age* **12**, 18, 20, 24, 28, 32 (Nov. 1948).

The printing of cotton, rayon, and linen fabrics is outlined, with suggestions for avoiding processing difficulties. Processing procedures will vary in accordance with the characteristics of the fiber making up the fabric. A. L. Landau

Text. Research J. May 1949

Treatment of Linen with Formaldehyde

Increasing the serviceability of pure linen. A. Richter. *Melliand Textilber.* **28**, 129–33 (1947)

(through *Chem. Abstr.* **42**, 8481*a* (Nov. 10, 1948)).

Linen fabrics can be made more resistant to alkaline washing solutions by treatment with HCHO. It is considered that the pectins and other binding materials are hardened and become less soluble in alkali.

Text. Research J. May 1949

Fabric Shrinkage

The causes and elimination of fabric shrinkage. E. C. Pfeffer, Jr. *Rayon and Synthetic Texts.* **30**, 57–8 (Jan. 1949).

Factors causing shrinkage are discussed, with particular emphasis on rayon fabrics. Mention is made of a means of controlling shrinkage of rayons. Nylon is also considered briefly. L. A. Fiori

Text. Research J. May 1949

Shrinkage Control

Shrinkage control. E. Wilkinson. *Am. Dyestuff Reptr.* **37**, 733–5 (Nov. 1, 1948).

The improved wear of army woolen socks resulting from treatment to maintain dimensional stability has been so impressive that the U. S. Quartermaster Corps is studying the entire woolen field to determine which additional articles could satisfactorily be treated for the same reason. It is pointed out that dimensional stability is of most value for items which are subjected to repetitive cleansings, such as socks, underwear, shirts, sweaters, and athletic gear. C.A.A.

Text. Research J. May 1949

Control in Wool Scouring

Modern control methods in wool processing at the Fred Whitaker plant. J. Bauer. *Instrumentation* **3**, No. 8, 12–13 (1948) (through *Chem. Abstr.* **42**, 8480*d* (Nov. 10, 1948)).

Instrumentation is described dealing with the measurement and control of wool flowing from the bale breaker, controlling variables in wool scouring, wool drying, pH control in neutralizing, bleaching solution temperature, and also instruments for control laboratories.

Text. Research J. May 1949

Desizing Agents

Evaluation of enzymatic desizing agents. E. Schubert. *Textil-Rundschau* **3**, 295–304 (Sept. 1948); 335–42 (Oct. 1948).

The enzymatical desizing of textiles sized with starch is discussed in the light of our present knowledge of starch and starch-splitting enzymes. Commercial desizing preparations contain either pancreas, bacterial, or malt amylases. The properties of the 3 amylases are described. Bacterial and pancreas amylases are pure α-amylases (dextrinogen amylases, liquefying amylases); malt amylase contains α- and β-amylases (saccharogen amylases). The optimum temperature is discussed; generally, the higher the temperature, the shorter the reaction time. Amylase activities can be measured by liquefaction, saccharifaction, and dextrination. Liquefaction can only be used for α-amylases, saccharifaction is used for α- and β-amylases separately, and dextrination measures the effect of α- and β-amylases combined or of α-amylase alone. In the presence of sufficient β-amylase the dextrination effect of β-amylase is increased 5 times, but β-amylase alone has no dextrination effect. Any of these analysis methods is practical for bacterial and pancreas amylases but only dextrination can be used for analysis of malt amylase. None of these methods can be used to determine the desizing value of the preparations; desizing tests must be used. The author uses a modification of the Kehren desizing test. The results of analyses of amylases do not necessarily coincide with the results of the desizing tests. 52 references. J. F. Krasny

Text. Research J. May 1949

Size Mixtures

Preparing size mix. F. D. Herring. *Textile Bulletin* **74**, 57, 58, 60, 62 (Dec. 1948).

Characteristics of the yarn to be sized must be considered in preparing the size mixture because the mixture must be more viscous for short staple cotton; it is more difficult to prevent shedding if the draft at the spinning frame is very high; and hard twisted yarn is more difficult to penetrate with size. The count of the warp yarn or the number of threads in the warp should not generally change the size formula, although they will change the procedure at the slasher and the application of the size. Types of starches and softening agents, and the cooking of the size are discussed. A. L. Landau

Text. Research J. May 1949

Sizing Filament Rayon

Warp sizing nylon filament yarn. R. D. Bennet. *Can. Text. J.* **66**, 50, 52, 54 (Jan. 7, 1949).

The use of polymethacrylic acid textile size in relation to nylon filament yarn is discussed (formulas, mixing instructions, and effect on yarns during weaving). L. A. Fiori

Text. Research J. May 1949

Sizing Spun Yarns

The sizing of spun yarns. R. Morningstar. *Rayon and Synthetic Texts.* **30**, 55–6 (Jan. 1949).

Virtues of the cotton slasher features with respect to spun yarns are discussed. Mention is made of a suitable size product adaptable for general use and particularly for use with fiber combinations containing fibers which are difficult to size.

Text. Research J. May 1949 L. A. Fiori

Softening Materials

Anionic substantive softeners. E. D. McLeod. *Am. Dyestuff Reptr.* **37**, P30–3 (Jan. 12, 1948).

A discussion of the chemical constitution of the substantive softening materials and the factors involved in their action on the light-fastness of dyed goods. The development of anionic substantive types is described and their several advantages—notably, lack of effect on light-fastness—over cationic types are discussed.

K. S. Campbell

Text. Research J. May 1949

Wet Processing

Vocational texts in practical wet processing. South Central Section, A.A.T.C.C. *Am. Dyestuff Reptr.* **37**, 788–91 (Nov. 29, 1948).

This paper outlines a vocational guidance course for textile operators at the mill-worker's level. In addition to the preliminary general statements, and a listing of suitable textbooks, 2 adjuncts of the paper are given. The first adjunct, by H. A. Webb, pertains to cotton printing, and it deals with the printing machine, printing pastes, agers, and the method for printing with various classes of color. The second adjunct, concerned with textile auxiliaries, was prepared by A. J. Kelly. Products generally used in scouring, bleaching, dyeing, and finishing operations, such as soaps, bleaching agents, softeners, sizing and filling materials, water repellents, mildewproofing and mothproofing compounds, synthetic resins or plastics, and fire retardants are discussed. C.A.A.

Text. Research J. May 1949

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Blends—Influence on Yarn and Fabric Design

Influence of mixed fibres on yarn and fabric design. R. Wood. *Can. Text. J.* **65**, 44–6, 48 (Nov. 12, 1948).

Outlined is the mechanical approach to the selection and use of fibers which will assure desirable characteristics in yarns and fabrics for wearing apparel and other uses. Formulas for predicting the spinning limits of the various types of staple fibers used singly and in combination in blends are presented.

Text. Research J. May 1949 L. A. Fiori

Jute Cellulose

Jute fiber as a source of cellulose. P. B. Sarkar. *J. Sci. Ind. Research* (India) **7B**, No. 2, 21–4 (1948) (through *Chem. Abstr.* **42**, 7524*d* (Oct. 10, 1948)).

Jute fiber, having useful applications in the textile field, cannot be considered as an economical replacement for cotton linters as a source of cellulose. Waste jute or jute products, however, may be a valuable supplementary source of α-cellulose in India. Complete removal of lignin from jute fibers is easily achieved by treatment with 0.7% $NaClO_2$ at 100°C, giving holocellulose; this, treated with 9.3% NaOH at room temperature, gives α-cellulose of quality suitable for the preparation of viscose rayon or cellulose acetate (cf. C.A. **42**, 2107*g*).

Text. Research J. May 1949

Nylon in Half Hose

Nylon staple in men's half hose. R. D. Bennet. *Can. Text. J.* **65**, 50, 84 (Nov. 12, 1948).

The use of nylon staple as a 100% yarn or in percentage blends with wool is said to offer many advantages including shrinkage-resistance, abrasion-resistance, ease of washing, comfort and warmth, and good appearance. A summary of some wear test results. L. A. Fiori

Text. Research J. May 1949

Re-Manufacture of Nylon Fabric Waste

The re-manufacture of knitted nylon fabric waste. P. P. Townend and C. Scerb. *Textile Recorder* **66**, 65–8, 70 (Nov. 1948).

A detailed account of an attempt to reduce knitted nylon hosiery waste to a fibrous form suitable for processing with wool on the woolen spinning system. It was concluded that with the addition of nylon shoddy to the blend a stronger yarn and fabric is produced, more than 10% by weight of nylon on the weight of the wool does not materially affect these strengths, extension at break is not materially altered, even after vigorous rubbing trials cloth strength is preserved, and shrinkage is slightly reduced. Methods of shredding the nylon hose are given considerable attention. 10 tables of data.

Text. Research J. May 1949 L. A. Fiori

Plastic Coated Yarn

Scotland produces Plexon, the new plastic coated yarn. Anon. *Silk J. & Rayon World* **25**, 40 (Dec. 1948).

A short account of the many uses and advantages of the plastic-coated yarn, Plexon. L. A. Fiori

Text. Research J. May 1949

"Burning Properties of Sisal"

Sisal fibers versus wet water. D. Powell. *Safety Eng.* **96**, No. 2, 22–3, 50 (1948) (through *Chem. Abstr.* **42**, 9183*h* (Nov. 20, 1948)).

Sisal, used as a substitute for Manila fiber, has a high flammability. But a new wetting agent has been developed which is proving to be a satisfactory fire extinguisher for sisal.

Text. Research J. May 1949

Terylene—A New Fiber

Terylene, the new British fiber. W. H. Cady. *Am. Dyestuff Reptr.* **37**, 699–702 (Oct. 18, 1948).

The process for producing the terylene fiber from ethylene glycol and terephthalic acid is described. The formula for terylene is compared with that for nylon, and the differences are pointed out. It is well adapted for weaving and knitting, as its tensile strength is outstanding and is only slightly lessened on wetting. Ordinary dry-cleaning solvents have no effect on it. It resists bleaching agents, boiling dilute mineral acids, and is reasonably stable to alkalies. Methods of coloring are briefly discussed. This fiber has temporarily been designated as "Fiber V."

Text. Research J. May 1949 C.A.A.

Vinyon N

Vinyon N resins and fibers. E. W. Rugeley, T. A. Feild, Jr., and G. H. Fremon. *Ind. Eng. Chem.* **40**, 1724–31 (Sept. 1948).

The copolymer resin used for the manufacture of the new Vinyon N fiber is composed of vinyl chloride and vinyl cyanide or acrylonitrile (CH_2:CHCN) containing 56–60% of the chloride. It has greatly

improved solvent resistance, better dye affinity, and higher softening points than the older Vinyon types which were chloride acetate copolymers. The copolymerization ratio of vinyl chloride and acrylonitrile is rather high in favor of the acrylonitrile and it is necessary to feed acrylonitrile continuously during the copolymerization reaction in order to obtain resins of the degree of compositional uniformity desired for fiber applications. The conversion of resin to fiber or yarn form is accomplished by either the dry or wet spinning process, depending upon the particular qualities desired in the finished product. Acetone is used as the solvent. Vinyon N fibers cannot be cold-drawn but at elevated temperatures (117–170°C) the operation proceeds smoothly and the fiber attains a very high degree of molecular orientation. Tenacity increases regularly with increases in the degree of stretch. Stretches as high as 2,500% based on the spun yarn, and filament deniers as low as 0.35 have been attained in experimental work, but in practice the filament denier of the stretched yarn usually falls within the range 0.75–2.0. The amount of shrinkage suffered at any given temperature by yarn made with a given degree of stretch is highly reproducible, and because there are definite applications for yarn with this characteristic, some stretched yarns are marketed without further treatment. Where better dimensional stability or superior resistance to solvents is required, some degree of heat treatment of the stretched yarn is indicated. When stretched yarn is heat-modified on rigid bobbins, a final product is obtained which is characterized by excellent tenacity, high yield point, and relatively low elongation. Highly modified yarns can withstand boiling acetone without damage. Vinyon N fibers become progressively more stable as the degree of stretch is increased above about 500%. Color and color stability of the yarn in sunlight appears to be closely related. Small amounts of stabilizers can be used to good advantage and in practice one or more are added to the spinning solution. The most effective stabilizers for Vinyon N fibers to date have been the organo-tin compounds. They also prevent discoloration of the yarn as a result of exposure to sunlight. All Vinyon N grades have about the same color after 200 Florida sun-hours as they had originally and the over-all effect of sunlight on color is a slight bleaching during the early stages of exposure, followed by a slow return to the original shade.

A. R. Macormac

Text. Research J. May 1949

Chlorination of Wool

Some aspects of the chlorination of wool to produce shrink-resistance. M. Harris and D. Frishman. *Am. Dyestuff Reptr.* **37**, P52–6 (Jan. 26, 1948).

The cause of wool shrinkage is discussed, and the chlorination process for imparting shrink-resistance is described, particularly with reference to the effect of the pH of the hypochlorite solutions. A pH of 8–9 gave minimum area shrinkage and low alkali solubility.

K. S. Campbell

Text. Research J. May 1949

Slubs in Worsted Yarn

Slubs in worsted yarn. R. S. Audley. *Fibres* **9**, 386–8 (Oct. 1948); **9**, 441–2 (Nov. 1948).

Discussed are (1) raw materials, (2) method of treating the material to avoid slubs, and (3) steps taken to remove slubs once they are formed. Factors examined include oil used, dyeing temperatures, pin treatment, care of leathers, relative merits of leather- against cork-covered rollers in drawing, etc. Prevention of slubs at as early a stage as possible is best. L. A. Fiori

Text. Research J. May 1949

New Method for Spinning Yarns

Centrifugal spinning of dry yarn. Anon. *Text. Mercury and Argus* **119**, 409, 411, 413–14 (Sept. 24, 1948); *Textile Weekly* **42**, 668, 670, 672, 674 (Sept. 24, 1948); *Fibres* **9**, 392–4 (Oct. 1948); and *Can. Text. J.* **65**, 44–6, 48 (Oct. 15, 1948).

Presented is a new "P.S.C." system for centrifugal spinning of dry yarn. Based on the practice of inserting twist by the "pot spinning" principle, its main features are the hollow containers which hold the yarn as it is being spun, and the automatic doffing system which removes the yarn from the container sides in usable form. Some of the more important claims are: no piecing-up labor, larger packages, higher speeds, ability to run unattended under special conditions, and fewer end breakages. The principle, illustrated by diagrams, is explained in detail. It also embraces roving and twisting machines. L. A. Fiori

Text. Research J. May 1949

Cotton Carding

Progress in cotton carding. Anon. *Textile Weekly* **42**, 1066, 1068, (Nov. 12, 1948).

Introduced is the "Nuclotex" system of carding. It comprises a secondary licker-in which is used in conjunction with but after the existing or primary licker-in and just before the main cylinder. Essentially, it is a double licker-in carding system. The primary licker-in strikes down at the lap feed, carries the first-stage opened cotton past the mote knives and screen, and throws it onto a smaller diametered, faster-running, secondary licker-in having a metallic tooth fineness about halfway between that on the ordinary licker-in and card cylinder fillet proper. Among many advantages mentioned are: (1) "Nuclotex" carding fully maintains fiber strength, and in the majority of cases increases it; (2) at the card web and on yarn blackboard tests results were superior to those obtained by ordinary carding; and (3) by producing a semi-combed card web, card room re-spacing is a possibility, thereby doing away with 1 card in every 3 in fine-count mills. A diagram showing the application of this secondary licker-in on an existing card machine is appended.

Text. Research J. May 1949 L. A. Fiori

Picker Beaters

The beater section. R. Z. Walker. *Textile Bulletin* **74**, 52, 54, 57 (Dec. 1948).

Picker performance is dependent upon the condition of the stock fed to it, it is claimed. The settings of the beater, grid bars, and cut-off blade are discussed with respect to the factors affecting them.

A. L. Landau

Text. Research J. May 1949

New Whitin Comber

Whitin's new-model comber. Anon. *Am. Wool and Cotton Reptr.* **53**, 15–16 (Dec. 2, 1948).

A description of the new Whitin 8-head comber. It is claimed that at 150 nips per minute the comber is capable of higher production of more even sliver with better fiber distribution. A. L. Landau

Text. Research J. May 1949

Knitting Needles

Proper needles are important. G. Ransom. *Textile Age* **12**, 7, 10, 14, 16 (Dec. 1948).

The selection of knitting needles should be governed by the type of knitting to be done. The needle, whether latch or spring, should be hard but not brittle and should be smoothly finished. It is stated that the most important quality of the needles in a machine is uniformity of size. A. L. Landau

Text. Research J. May 1949

High Draft System

Casablanca's high draft. Anon. *Textile Weekly* **42**, 1178, 1180–1 (Nov. 26, 1948).

A brief explanation of the "Casablanca" system of drafting and its application to various phases of yarn manufacturing—namely, spinning and roving. L. A. Fiori

Text. Research J. May 1949

New High-Draft System

The Shirley high-draft system. Anon. *Textile Weekly* **42**, 1244, 1246 (Dec. 3, 1948); *Text. Mercury & Argus* **120**, 13, 15 (Jan. 7, 1949).

Described briefly is a newly developed high-draft system applied to ring spinning frames. It is stated that a very wide variety of yarns can be spun—from the shortest-staple Indian up to long-staple Egyptian cottons. A limiting factor is that special attention is required during processing prior to spinning to see that roving is not overtwisted, inasmuch as this system performs better with low-twist rovings. Yarn quality is maintained and in some instances is improved over that of other systems. Possibilities of applying this system to the spinning of rayon staple and in blends is excellent.

Text. Research J. May 1949 L. A. Fiori

Saco-Lowell New Era Spindle

New spindle design promises many savings. Anon. *Am. Wool and Cotton Reptr.* **53**, 15, 16, 25, 26 (Dec. 23, 1948).

A description of the Saco-Lowell New Era Spinning Spindle. The spindle is a radical departure from the conventional design, as only the package carrier revolves. The carrier is supported by 2 ball bearings, one under the whorl and the other at the top of the supporting shaft, which need lubrication only every three years. Advantages claimed are reduction in driving power, less maintenance, longer tape life, and lower cost of lubrication.

A. L. Landau

Text. Research J. May 1949

Twist

Some new kinks on twist. Anon. *Am. Wool and Cotton Reptr.* **53**, 11–12 (Sept. 16, 1948).

A study of the principles governing the effect of twist on fibers. The fiber length is one of the main determining factors in predicting the twist multiplier for a given hank roving, and is the limiting factor in the range of hank roving which it is possible to produce from a given fiber. The size of the roving frame must be suited to the size of the hank roving to be made.

A. L. Landau

Text. Research J. May 1949

Some new kinks on twist. Anon. *Am. Wool and Cotton Reptr.* **53**, 15, 16, 25 (Sept. 30, 1948).

The derivation of the formula for computing twist is given (turns per inch = twist multiplier × square root of count). The effect of the amount of twist given a strand of fibers in spinning and the direction of twist in the twisting operation are also discussed. A. L. Landau

Text. Research J. May 1949

Winding Process

Analysis of the winding process of the spinning mule. F. Oertel. *Textil-Rundschau* **3**, 331–5 (Oct. 1948).

The method of winding a bobbin on a mule and the use of the quadrant mechanism are discussed. Equations for the winding curves are derived. J. F. Krasny

Text. Research J. May 1949

Looms

Looms: Reed moves independently from lay. L. Vigneul. *Industrie textile* **1948**, 275 (through *Textil-Praxis* **3**, 363 (Nov. 1948)).

The number of picks per min. can be increased by making the movement of the reed independent of that of the lay, thus giving the shuttle more time to complete its traverse motion. The reed is moved by a separate lever arrangement.

Text. Research J. May 1949

Repairing Loom Shuttles

Repairing loom shuttles by a new "wood welding" device. Anon. *Textile Recorder* **66**, 72 (Nov. 1948).

The application of radio-frequency heating technique reduces the time of repairing shuttles from hours to minutes. A brief description of the process is given. L. A. Fiori

Text. Research J. May 1949

Hot-Air Warp Driers

Hot-air warp driers. Anon. *Textile Inds.* **112**, 127–9, 131, 133, 135 (Dec. 1948).

A description of the construction and operation of the hot-air warp driver. The drying medium contains inert products of combustion and superheated water vapor, both of which have great affinity for water and eliminate oxidation from occurring when heated air is used for drying. The usual range of speeds is from 70–90 yds. per minute. Size mixtures, wet splitting of warps on regular slashers, and other phases of slashing are discussed. A. L. Landau

Text. Research J. May 1949

Electronically Controlled Warper

Electronically controlled warper. E. S. Lammers and J. C. Bodansky. *Textile Inds.* **112**, 89–91 (Dec. 1948).

An electronically controlled warper is claimed to give higher speeds, wider speed range, soft acceleration, constant yarn speed, and close speed regulations. The warper is driven and controlled by a motor-generator set, starter, and speed regulator. A. L. Landau

Text. Research J. May 1949

New Woolen Condenser Bobbin

The Aerobobbin. Anon. *Platts Bull.* **6**, 93–4 (Sept.–Oct. 1948); and *Text. Mercury and Argus* **119**, 688 (Nov. 12, 1948).

Introduced is a new condenser bobbin—the Aerobobbin, which is lighter, tougher, and of simpler construction than that of the wooden bobbin. It has an aluminum barrel and duralumin flanges, is unaffected by climatic conditions, has no external screws or other projections, and is easily dismantled and reassembled. L. A. Fiori

Text. Research J. May 1949

Yarn Breaks

Yarn breaks on the ring spinning machine. O. Johannsen. *Textil-Praxis* **3**, 295–301 (Oct. 1948).

It was found that, in spite of even tension at all times, the number of breaks during spinning at the top of the cops increased when spindle speed regulators were installed. The centripetal pull of the yarn on the traveler causes the latter to run with the friction and/or vibration, but this force can be balanced by the centrifugal force imparted by the balloon. Speed regulation decreases the centrifugal force too much for good traveler balance. The force conditions are investigated, and formulas are given for the friction between yarn and traveler, for the "disturbance of traveler balance," and for traveler pressure on the ring. Data were found by various mechanical measuring devices. J. F. Krasny

Text. Research J. May 1949

Means to decrease the number of yarn breaks on the ring spinning machine. N. D. Lebedew. *Tekstil. Prom.* **1948**, 6, p. 22 (through *Textil-Praxis* **3**, 323 (Oct. 1948)).

Yarn breaks are caused by actual stopping of the travelers due to friction and vibration for as little as 0.0035 second. A formula for the mathematical determination of stoppage time is given. A new device for ring polishing is described.

Text. Research J. May 1949

Reduction of yarn breaks in woolen spinning. S. A. Rjabzew. *Tekstil. Prom.* **1948**, 6, p. 17 (through *Textil-Praxis* **3**, 361 (Nov. 1948)).

A piece of roving is held by two clamps. By rotating one clamp, twist is inserted; by moving the other, the roving is drawn out until it breaks. Optimum conditions for draft and twist can be determined experimentally.

Text. Research J. May 1949

Extension of Pin Control in Worsted-Type Yarn Processing

Extension of pin control in worsted-type yarn processing. J. R. Longstreet. *Textile Bulletin* **74**, 45, 46, 48, 50 (Aug. 1948).

A summarization of the advantages of the pin drafter when used for either the Bradford, French, or American systems of spinning worsted yarn. The position of the pin drafter in the processing line of each of the 3 systems is discussed.

A. L. Landau

Text. Research J. May 1949

MISCELLANEOUS

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Electronically Cleaned Air

Improved textiles through electronically cleaned air. Anon. *Am. Wool and Cotton Reptr.* **53**, 11, 12, 49 (Dec. 23, 1948).

The efficiency of air-cleaning equipment is tested by comparing the discoloration resulting from particles deposited by the air entering the filtering agent with the discoloration deposited by the air on the exit side. It is claimed that the mechanical cleaner will show 10–30% efficiency in comparison with 85–95% for an electrostatic cleaner. The theory of operation of the electrostatic cleaner and its potential uses are discussed. A. L. Landau

Text. Research J. May 1949

Tagged Atoms

Tagged atoms offer new research tool. W. B. Dall. *Textile World* **98**, 103–7 (Dec. 1948).

The fact that a radioactive isotope can be followed and its path recorded is being utilized by textile engineers in both research and production-control fields. Examples of actual tests made and projected work are outlined. The theory of the radioactive atom is explained.

A. L. Landau

Text. Research J. May 1949

Cellulose Ethers

Cellulose ethers and their use in the textile industry. G. Sandor. *Textil-Rundschau* **3**, 417–23 (Dec. 1948).

The cellulose ethers discussed are methyl, glycol, and glycolic acid ethers. Their solubilities and viscosities can be modified by varying the conditions of reaction (*e.g.*, the degree of ripening of the soda cellulose). These products are used for sizing (water-soluble brands), as

thickening agents in printing pastes (particularly glycol and glycolic acid ethers), in textile finishing where water-soluble brands play a subordinate part in conjunction with starch finishes; the water-insoluble ethers, on the other hand, are very important for so-called permanent finishes which are fast to washing. These insoluble ethers are also used as fixing agents in textile printing. A list of products of Central-European manufacturers is given. Author

Text. Research J. May 1949

Oiling Cotton

Dust supression by preconditioning of cotton. H. Paton. *Textile Weekly* **42**, 1402, 1404, 1406 (Dec. 24, 1948).

The application of highly refined "technical white oils" to cotton is the best method of dust suppression. Such technical aspects as correct method of application, oil characteristics, suitable sprayers, amount of oil to be applied, etc., are described at some length. Results show that (1) dust reduction is greater than 50%, (2) wastes are much more compact and do not have a tendency to produce "fly," and (3) no significant reduction of yarn strength is apparent. On the whole, no detrimental results have been reported. L. A. Fiori

Text. Research J. May 1949

Cotton in Knitting Industry

Cotton in the knitting industry. F. A. McCord, R. Steinbach, Jr., and G. S. Buck, Jr. Memphis, Tenn., National Cotton Council of America, Dec. 1948. 21 pages.

This is another in a series of studies made by the National Cotton Council on the use of cotton in various industries. The knitting industry, consisting of more than 3,000 establishments, used 591,220 bales of cotton in 1939 and 784,600 bales of cotton in 1946, with cotton accounting for slightly more than half the yarn used during each year. Cotton consumption is said to have gained in men's underwear, polo, "T" and basque shirts, and in women's anklets, vests, and panties, and to have lost in men's dress hosiery and heavy underwear. Among needed improvements in cotton yarns for knitting are: (1) better uniformity, (2) lower bulk-strength ratio for tricot knitting, (3) better luster, (4) brighter dyes, (5) more loftiness and ability to retain loftiness where this is important, and (6) more smoothness and slipperiness for other uses. Statistical data are given on the consumption of fibers for each type of knit-goods production in 1939 and 1946. There are sections on advertising and mechanization, educational problems, prices, and the comparative quality situation for various fibers in different knit products. R. B. Evans

Text. Research J. May 1949

Cotton Marketing

Marketing practices at central spot cotton markets. R. C. Soxman and Arthur L. Roberts. Production and Marketing Administration, U. S. Dept. of Agriculture, Washington, D. C., Aug., 1948. 55 pp. Free.

Most cotton is purchased by merchants on the basis of actual samples, but substantial amounts are bought only on description. Merchants sell 94% of their cotton directly to spinners, but ⅓ is sold through brokers. The cost of merchandising cotton, including transportation, compression, etc., ranged from $6.70 per bale at Augusta to $9.85 at Houston during 1943–44. Cotton marketing agencies could improve marketing of cotton by insisting upon the use of a standard, light-weight, more protective bale-covering, automatic sampling at the gin, compressing cotton at the gin to a standard density, and permanent identification for bales. Greater recognition of quality differences is needed in local markets, and more attention should be given to the variety of cotton handled.

Text. Research J. May 1949 R. B. Evans

German Detergents

German synthetic detergents. Anon. *Soap and Sanit. Chemicals* **24**, 67, 69 (July 1948).

Abstract of review in *Soap, Perfumery & Cosmetics* **21**, 364–70 (1948).

Text. Research J. May 1949

Industrial Detergents

Detergents at home and in industry. G. G. S. Dutton. *Chem. Products* **11**, 104–7 (1948) (through *Chem. Abstr.* **42**, 8000*h* (Oct. 20, 1948)).

A critical review and analysis of talks given at a recent symposium of the London section of the Soc. Chem. Industry, dealing with the evaluation of detergents, development of synthetics, wetting agents, dispersing agents in industry, degreasing metals, and oil-in-water emulsions.

Text. Research J. May 1949

Identification of Textile Fibers

The identification of textile fibers. E. Moller. *Melliand Textilber.* **28**, 109–11 (1947) (through *Chem. Abstr.* **42**, 8479*e* (Nov. 10, 1948)).

A scheme for the identification of textile fibers, based on their behavior when burned.

Text. Research J. May 1949

World Fiber Production and Consumption

World fibers review, 1948. F. A. O. Commodity Series No. 9. Washington, Food and Agriculture Organization of the United Nations. 72 pages. Price, 25 cents.

World fiber production during 1947–8 totaled 10.2 million tons, compared with 8.5 million tons the preceding year and 11.9 million tons in 1938–9. The output of silk was down 76%; flax, 52%; hemp, 28%; rayon staple, 27%; cotton, 15%; wool, 7%; hard fibers, 12%; and jute, 5%, compared with prewar; while only rayon filament yarn was up, with a gain of 32%. With a 10% growth in world population during the last decade, the 1947–8 output of fibers per person was about 23% below prewar. Greater fiber production is expected for 1948–9. International trade is much more important for fibers than for foodstuffs, with large-scale pro-

duction of cotton, wool, silk, jute, and the hard fibers heavily concentrated in a few countries and with Europe and Japan the major fiber-importing regions. Growing shortages of foreign exchange have made transfer of fibers more difficult, but the latter is being stimulated by the Marshall Plan. Sections in the review are devoted to the world fiber situation and outlook and to reviews of the situation for each major fiber. Tables in the appendix give production of various fibers by countries, fiber prices, and "national balance sheets for fibers."

R. B. Evans

Text. Research J. May 1949

Retting Flax with Ozone

Defibering of flax with ozone. P. Eckert and E. Kanert. *Kunstseide u. Zellwolle* **25**, 247–51 (1947). Based on work of G. H. Campbell (U. S. Pat. 1,086,273, *C. A.* **8**, 1212) (through *Chem. Abstr.* **42**, 9182*i*–9183*a* (Nov. 20, 1948)).

Nonretted broken flax with straw was treated with ozonized air until the woody portions separated from the fibers. O_3 was prepared at 35°–40°C in approximately 5% concentration. The retting was carried out at 22°–28°C with 24–81 cu. m. hr. of air containing 0.02% O_3 over a period of 8–12 hrs. with a fiber yield of 23–30% and a fiber lignin content of about 7.0%. The higher yield was obtained at 12.5% H_2O during the preliminary roller-mill breaking as compared with 8% H_2O for the lower yield. No difference in fiber properties could be observed when compared with products of the usual retting process.

Text. Research J. May 1949

Fungicide for Textiles

Copper 8-quinolinolate industrial preservative. P. G. Benignus. *Ind. Eng. Chem.* **40**, 1426–9 (Aug. 1948).

Copper 8-quinolinolate, a light yellowish-green, odorless powder is a practically nonionizable chelated compound. Its water solubility is 0.8 part per million at 25°C. It is unaffected by acids or alkalies from pH 2.7–12. It is insoluble in common organic solvents, nonvolatile, stable up to 400°F, and appears to be unaffected by ultraviolet or other actinic rays. Patch tests indicate that it is non-toxic and non-irritating. In concentration of 1–5% on fabrics, it inhibits growth of various fungi and is resistant to soil-burial test. Exposures of treated fabrics at Barro Colorado Island, Panama Canal Zone, and Harbel, Liberia (Africa), indicate good stability to outdoor weathering conditions. It should be a good preservative for textiles, leather, wood, plastics, and many types of protective coatings.

A. R. Macormac

Text. Research J. May 1949

Laundry Germicides

Germicides for Army mobile laundries. T. H. Vaughn, A. L. Sotier, E. F. Hill, J. E. Simpson, and W. M. Lee. *Ind. Eng. Chem.* **40**, 2054–9 (Nov. 1948).

At the request of the Office of The Surgeon General, the Office of The Quatermaster General early in World War II directed studies to develop suitable means of sterilizing Army clothing in combat areas. Preliminary studies eliminated several important classes of germicidal materials. Chlorine-active organic compounds appeared promising, however. Of several chlorine-active chemicals studied, only Monochloramine B possessed solubility, pH, fading, and chlorine-liberating characteristics that were practical, as determined by tests in the laboratory. Temperature, exposure time, and pH are factors governing germicidal power when this chemical is used for laundering purposes. It was found that at pH 5.0 as little as 25 p.p.m. of available chlorine in laundering solutions containing moderately high amounts of organic material will kill *Staphylococcus aureus* in 3 min. at 38°C. Field trials of Monochloramine B in a mobile laundry unit at Camp Lee, Va., confirmed the laboratory findings to a remarkable degree. This was evidenced by greatly reduced counts of artificially infected swatches laundered with solutions of Monochloramine B, and by greatly reduced counts of the wash and rinse waters. While detailed studies for establishing optimum concentrations of the chemical for the job to be done were not undertaken, it was found that about 8 oz. per 60 gal. of water, used in the second clear water rinse, yielded the best results. The Navy has adopted this procedure as part of their Specification 37-R-3, dated June 19, 1944, covering the renovation of Navy Special Clothing.

Text. Research J. May 1949 Authors

Carob Gum

The constitution of carob gum. F. Smith. *J. Am. Chem. Soc.* **70**, 3249–53 (Oct. 1948).

Carob gum, a polysaccharide obtained from the seeds of the carob bean, is composed of *D*-galactose (20%) and *D*-mannose (80%). Upon methanolysis the methylated gum obtained either directly or through the acetate by the agency of methyl sulfate and sodium hydroxide gives the glycoside of 2, 3, 4, 6-tetramethyl-*D*-galactose (1 part), 2, 3, 6-trimethyl-*D*-mannose (2–3 parts), and 2,3-dimethyl-*D*-mannose (1 part). These constituents have been identified by the formation of crystalline derivatives. The structure of the galactomannan polysaccharide is discussed. Author

Text. Research J. May 1949

Economics of Instrumentation

The economics of instrumentation. C. W. Bowden, Jr. *Am. Dyestuff Reptr.* **37**, 647–51 (Oct. 4, 1948).

Any equipment which is installed in a mill must justify all costs involved in its purchase, operation, and maintenance by contributing to product quality and uniformity, reduction of waste, and reduction of production costs. In the textile industry, chemical processes offer almost unlimited opportunity for adoption of instruments, but mechanical processes offer less opportunity. Equipment for batch-dyeing control, continuous bleaching, squeeze-roll loading, saturator control, the J-box, and control of washing are discussed. An example of the econ-

omy of "bleaching controls" is included. C.A.A.

Text. Research J. May 1949

Wet Strength of Paper

The wet strength of paper. I. Burszytn. *Brit. Plastics* **20**, 299–304 (July 1948).

A study of the role of amino resins in improving the wet strength of paper. Color photographs show the mechanism of binding of urea-formaldehyde and of melamine-formaldehyde resins. Correlations between photographic and tensile data were given for kraft and sulfite paper, both bleached and unbleached. J. P. Tordella

Text. Research J. May 1949

Cellulose Ester Plastics

Cellulose ester plastics—Plasticizing action of homologous series of esters of sebacic and phthalic acids on cellulose acetate butyrate. L. W. A. Meyer and W. M. Gearhart. *Ind. Eng. Chem.* **40**, 1478–85 (Aug. 1948).

The physical properties of plastics compounded from cellulose acetate butyrate and homologous series of phthalate and sebacate esters show fairly good correlation with the solvent ability of the plasticizer for the polymer as determined by viscosity relationships of dilute solutions of the cellulose esters in a mixed solvent consisting of plasticizer and acetone. The toughness of the plastics at low temperature shows some correlation with the viscosity temperature relationship of the plasticizers. More data on this and other polymer systems are needed to establish more generally the relationship between the physical properties of the plastic and the solvent power of plasticizers over a temperature range. Authors

Text. Research J. May 1949

Plasticizers for Vinyl Chloride-Acetate Resins

Behavior of plasticizers in vinyl chloride-acetate resins. M. C. Reed and L. Connor. *Ind. Eng. Chem.* **40**, 1414–22 (Aug. 1948).

Vinylite resin VYXW (5 parts acetate and 95 parts chloride) was made into sheets using 30, 35, and 40% of 99 different plasticizers. The trade names and/or chemical compositions and sources of the plasticizers are listed. Plasticizing efficiency is shown by elongation at 1,000 lbs. per sq. in. at 10°, 25°, and 40°C. Data are also given for volatile loss, oil extraction, water extraction, flex temperature, and compatibility with the resin. The volatile loss depends upon the thickness of the film and time of exposure. An equation for converting rate of plasticizer volatilization on an accelerated basis to other conditions of exposure is presented. Data on 36 of the plasticizers used in combination with 20% tricresyl phosphate are given. Low vapor pressure and good chemical stability are essential to permanence in the plasticized composition.

A. R. Macormac

Text. Research J. May 1949

Degradation of Rayon During Washing

Stability towards boiling of staple rayon and the effect of washing procedure. A. Zart. *Kunstseide u. Zellwolle* **29**, 263–4 (1947); cf. C. A. **38**, 4135[6] (through *Chem. Abstr.* **42**, 9184g (Nov. 20, 1948)).

Boiling with 0.5% Na_2CO_3 in the presence of air did not reduce the strength, but decreased the D.P. from 340 to 298. Machine washing exposes the fabric to more air and thus causes greater degradation.

Text. Research J. May 1949

Rayon Manufacture on West Coast

Potential rayon manufacturing facilities on the West Coast. Paul W. Frisk. *Rayon and Synthetic Texts.* **29**, 55–8 (Sept. 1948).

A cost of more than 2½¢ per pound is involved in the shipping of rayon to the West Coast. All the raw materials required for rayon manufacture are said to be available in that area, but no cost data are given. Gas and electricity rates are said to be competitive with the lowest rates in the South. Apparel manufacture in California is growing rapidly, and well over 100,000,000 yards of fabric are now woven annually in that state.

Text. Research J. May 1949 R. B. Evans

Latex Treatment of Rayon Tire Cord

Behavior of rayon tire cord during latex dipping. H. H. Gillman and R. Thoman. *Ind. Eng. Chem.* **40**, 1237–42 (July 1948).

The large-scale usage of GR-S has markedly accelerated the trend to the use of rayon cord in tires. In 1946, approximately 40% of 500,000,000 lbs. of tire fabric was rayon. Because rayon tires can be made thinner, there is less heating in use. Two types of rayon tire cord were studied by latex dipping in a laboratory treating unit. Because of the smooth continuous-filament form of rayon tire cord, it must be treated with an adhesive before dipping. Staple fiber rayon and cotton do not require adhesives. A rayon cord lubricated with sulfonated oil picked up 2 to 4 times as much solids as one lubricated with a waxy ester. Water was taken up by the rayon at a faster rate than the latex, with the result that the latex bath became more concentrated. Adhesion is a function of solid pick-up and by changing the squeeze-roll pressure or the bath concentration, the solid pick-up can be varied. Data to support these conclusions are given and their significance is discussed. A. R. Macormac

Text. Research J. May 1949

Lowering the Swelling of Viscose in Water

Dimethylol-*p*-cresol, an aid to improvement of staple rayon flake and textiles in their resistance to swelling. W. Winkler. *Kunstseide u. Zellwolle* **26**, 114–17 (1948) (through *Chem. Abstr.* **42**, 9184*f* (Nov. 20, 1948)).

Treatment with dimethylol-*p*-cresol lowers alkali-solubility and swelling in water, but has little effect on the elasticity of the fiber.

Text. Research J. May 1949

Silicones in Textiles

Silicones and their application to the textile industry. F. L. Dennett. *Am. Dyestuff Reptr.* **36**, P748–53 (Dec. 15, 1947).

The use of silicones as insulating and protective coatings at high temperatures, as high temperature lubricants, as anti-foam agents, and as durable water-repellent finishes is discussed. K. S. Campbell

Text. Research J. May 1949

Manufacture of PotatoStarch

Manufacture of white potato starch—Comparison of batch and continuous processes. W. W. Howerton and R. H. Treadway. *Ind. Eng. Chem.* **40**, 1402–7 (Aug. 1948).

The annual production capacity for white potato starch in the U. S. is about 100,000,000 pounds, mainly in Maine and Idaho. Culls and surplus potatoes are used. The manufacture in two typical 10-ton-per-day factories was studied. One used a batch process in which grinding, screening, and drying were continuous but the settling and purification were batch processes. The other used a continuous process (more modern) in which tables were used for starch settling. Flow sheets on both processes are given. The continuous process yield was 85% starch compared with 71% for the batch process. The waste materials from the continuous process contained, on a dry basis, 24% starch and 32% protein as compared with 45% starch and 28% protein in the waste from the batch process. Both wastes are potential livestock feeds. A. R. Macormac

Text. Research J. May 1949

Tension Meters

Use of tension meters in textile mills. E. J. Saxl. *Can. Text. J.* **65**, 52, 54, 69 (Nov. 12, 1948).

A practical discussion and description of a modern tension meter and its method of operation in testing warps and fillings. Correct or "right tension" for a given yarn is defined. L. A. Fiori

Text. Research J. May 1949

Textile Dust Problems

Dust removal from textile factories. G. E. Shuttleworth. *J. Inst. Heating Ventilating Engrs. (London)* **16**, No. 155, 128–59 (1948) (through *Chem. Abstr.* **42**, 9185*h* (Nov. 20, 1948)).

The processing of cotton from the field through the mill is described. Sources of dust in each stage and means of removing it are discussed. The preparations of flax, hemp, and jute also are described, with their dust problems.

Text. Research J. May 1949

Textile Wastes

Some future problems in sewage purification at Bradford. C. C. Beedham. *Surveyor* **106**, 611–15 (1947) (through *Chem. Abstr.* **42**, 6027*i* (Aug. 20, 1948)).

The sewage treated at Bradford (England) is primarily effluent from the wool-scouring and -dyeing industries. The emulsified liquor has an oxygen demand of 6,000 parts per million, and contains 3,000–30,000 parts per million of grease, which is separated by treatment with H_2SO_4 to a pH of 3.5. However, the best liquor for biological treatment has a pH of 6.0–6.5. By acidifying only the strong, grease-containing effluents, acid is saved and the filter feed has a higher pH. Effluents containing synthetic detergents must be mixed with weak sewage to effect precipitation. By recirculating the effluent, the filters are kept working continuously. *Cf.* Hillier, *C. A.* **42**, 5592*g*.

Text. Research J. May 1949

Wear-Resistance Measurement

Measuring wear-resistance of man-made fibers. J. R. Stewart. *Can. Text. J.* **65**, 41, 44–5 (Oct. 29, 1948).

A brief review of some laboratory tools and methods developed in the last 12 years used in solving the problems of serviceability assay of man-made fibers. L. A. Fiori

Text. Research J. May 1949

Wool Fat

The composition of wool fat. IV. The sheep skin as the biosynthetic organ of triterpene alcohols. E. Lederer and D. Mercier. *Biochim. et Biophys. Acta* **2**, 91–4 (1948) (in French); cf. *C.A.* **40**, 4898[7] (through *Chem. Abstr.* **42**, 6137*d* (Aug. 20, 1948)).

Of all the organs examined, only the skin of the sheep contains the triterpene alcohols characteristic of wool grease—namely, lanosterol and agnosterol, in comparable amounts. It was concluded that the probable site of the biosynthesis of these compounds is the sebaceous glands.

Text. Research J. May 1949

Wool Manufacture in Canada

Expansion of wool textile production (in Canada). B. K. Gunn. *Can. Text. J.* **65**, 23–4 (Oct. 29, 1948).

Wool cloth made available per person in Canada is 35% above prewar, partly because of increased imports. Textiles now comprise 50% of British imports to Canada. With high wages and low tariffs, Canadian textile mills must be highly efficient. Canadian textile mills invested $135,000,000 on new construction and machinery during 1945–8, equal to 40% of the entire capital invested in 1939, and now employ 47,900 persons, 55% more than in 1939. The rate of population increase in Canada is said to be double prewar.

Text. Research J. May 1949 R. B. Evans

Paper Yarns

Technical advantages in the manufacture of paper and pulp yarns. O. Pennenkamp. *Deut. Papier-Ztg.* **1**, 20–2 (1947) (through *Chem. Abstr.* **42**, 9173*g* (Nov. 20 1948)).

Details are given of the preparation of paper, pulp, and Zellulon yarns and some of their properties. Each yarn has an optimum degree of twist and moistening. By the selection of suitable impregnating agents, the wet-strength values can be increased to 60–75% and, in some cases, even to 100% of the dry strength.

Text. Research J. May 1949

Yarn Numbering Systems

Numbering textile fibres and filaments. S. Blackshaw. *Can. Text. J.* **65**, 58–9 (Nov. 26, 1948).

The Integral and the Tex systems are compared, the magnitude of both being measured in terms of the denier system of numbering filaments and fibers. Figures furnished by the comparison help point out the merits or demerits of both systems. It is found that denier size numbers are too small while Tex numbers are too large. Integral size numbers place commercial fibers and filaments within the range of 2-figure numbers.

Text. Research J. May 1949 L. A. Fiori

An international yarn numbering system. Anon. *Textil-Praxis* **3**, 333–4 (Nov. 1948).

A German order of Mar., 1942, made the use of the metrical number (lengths in meters divided by weight in grams) obligatory except for filamentous rayon and silk. This system is preferred by some to the one proposed at the ISO meeting at Buxton, England, in June, 1948.

Text. Research J. May 1949 J. F. Krasny

Regeneration of Spinning Bath

Equipment for regeneration of spinning baths. Present state and future development. H. Busath. *Kunstseide u. Zellwolle* **25**, 284–8 (1947) (through *Chem. Abstr.* **42**, 9182*c* (Nov. 20, 1948)).

An illustrated discussion of the engineering developments for concentration of the spinning bath liquors from the viscose process and crystallization of $Na_2SO_4 \cdot 10H_2O$.

Text. Research J. May 1949

Spontaneous Combustion

Spontaneous combusion of oiled textile materials. M. Kehren. *Textil-Rundschau* **3**, 409–17 (Dec. 1948).

Oil added before spinning and/or opening may cause spontaneous combustion of textile materials, especially wool, or, in other cases, the heat produced might make the material harder to spin even though combustion does not take place. The author makes a survey of the oxidation properties and reactions of various oils, including linseed, peanut, olive, and mineral oils. Results of the Mackey test (which is not described in the paper) for the combustibility of various oils are discussed. Iron soaps, formed when some oils are stored in iron barrels, act as catalysts, as do chromium soaps. Beta-naphthol, hydroquinone, etc., are negative catalysts; the author does not recommend their use, however, because he fears they might react with the fiber or a dyestuff and thus become inactive. Mineral oils present no danger of oxidation but are difficult to remove in scouring. Temperature and moisture control of the wool, conservative use of reliable wool oils, and appropriate storage conditions are recommended. J. F. Krasny

Text. Research J. May 1949

Picker Distributing Systems

Picker distributing systems. R. Z. Walker. *Textile Bulletin* **53**, 53, 54, 56, 58 (Oct. 1948).

An analysis of the development of the modern picker distributing system, and a detailed explanation of the operation of present equipment.

A. L. Landau

Text. Research J. May 1949

Presser Arm on Roving Frames

The construction of the presser arm on the roving frame. E. Baltz. *Textil-Praxis* **3**, 378–9 (Dec. 1948).

A theoretical analysis of the dynamics of the presser arm on the flyer is given, and a practical example is included. With increasing diameter of the roving spool the pressure exerted by the pressure arm decreases. The author concludes that a spring would give better regulation of the pressure than does the currently used centrifugal action of the weight. No practical experience with the suggested device is claimed. J. F. Krasny

Text. Research J. May 1949

Selvedge Marking Machine

A new selvedge marking machine. Anon. *Textile Recorder* **66**, 62–3 (Dec. 1948).

Introduced is a new selvedge-marking machine incorporating these main features: instant-drying plastic pigment in place of the usual marking inks; letter-type dies which can be changed quickly and simply, resulting in a complete change of name or design in 2 min.; device for intermittently feeding material and making allowances for irregularities of width; and synchronization of all motion to ensure accurate and low-cost operation. L. A. Fiori

Text. Research J. May 1949

Winding

Improved British pirn winding machine. Anon. *Textile Recorder* **66**, 58–60 (Dec. 1948).

Completely modernized, this machine incorporates an entirely new type of builder motion, an improved heavy main shaft drive, and an enclosed worm-wheel drive.

Text. Research J. May 1949 L. A. Fiori

Use-Development Organization

The functions of a use-development organisation in the textile industry. H. A. Thomas. *J. Text. Inst.* **39**, P444–60 (Aug. 1948).

Purposes of a use-development organization are said to be (*a*) to develop uses for new products and new uses for established products, (*b*) to inform the research department of the utilization needs not met by existing products, (*c*) to coordinate all work concerned with new or improved uses, (*d*) to exercise budgetary control on use-development work, and (*e*) to inform trade of uses by means of demonstrations, samples, advertising, lectures, etc. Organization charts for a use-development organization are presented. R. B. Evans

Text. Research J. May 1949

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research for the benefit of the textile
industries and their allied branches

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